

Essentials of Nematodology
Edited by K. I. Skrjabin
Vol. XXII

V. M. Ivashkin, A. A. Sobolev, and L. A. Khromova

Camallanata of Animals and Man
and Diseases Caused by Them

Translated from Russian

Academy of Sciences of the USSR • Helminthological Laboratory
ESSENTIALS OF NEMATODOLOGY, Volume XXII
Edited by Academician K.I. Skrjabin

V. M. Ivashkin, A. A. Sobolev, and L. A. Khromova

Camallanata of Animals and Man and Diseases Caused by Them

(Kamallanaty zhivotnykh i cheloveka i vyzyvaemye imi zabolevaniya)

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5 FOREWORD

Volume XXII of "Essentials of Nematodology" contains descriptions of all species of the suborder Camallanata Chitwood, 1936, which parasitize in man and animals throughout the world. By the collection and study of the large body of data published in the Soviet and world literature during the last 150 years and its analysis, the authors have obtained a radical revision of the classification of these interesting helminths.

The large superfamily Cucullanoidea has usually been included in the suborder Camallanata although the species of this superfamily show morphological characters which are not characteristic for typical Camallanata. V. M. Ivashkin and myself (1968) removed the Cucullanoidea from the suborder Camallanata and established for them the new suborder Cucullanata with the two superfamilies Cucullanoidea Ivaschkin, 1962 and Gnathostomatoidea Skrjabin and Ivaschkin, 1968.

The classification of the Camallanata underwent another revision when the present authors established the new superfamily Anguilliculoidea which, together with the superfamilies Camallanoidea Travassos, 1920 and Dracunculoidea Cameron, 1934, form the suborder Camallanata.

The new superfamily contains four families, including the family Skrjabillanidae, established in 1958 by A. A. Shigin and N. G. Shigina, who placed it in the superfamily Dracunculoidea. The family Skrjabillanidae originally contained only the single genus *Skrjabillanus*, but the authors of this work included also the genera *Agrachanus* Tichomirova n. g. and *Molnaria* Moravec, 1968.

The authors consider the new superfamily Anguilliculoidea, the species of which show a combination of the characters of such different superfamilies as the Camallanoidea and the Dracunculoidea, as transitional between these two superfamilies.

In the superfamily Dracunculidae Cameron, 1934 the authors place only the families Dracunculoidea Leiper, 1912 and Philometridae Baylis and Daubney, 1926.

The first family preserves its former structure, but the Philometridae, which previously contained only the subfamily Philometrinae Yamaguti, 1935, is considered also to contain the new subfamily Philoneminae, with the single genus *Philonema* Ekbaum, 1933 because of the characteristics of the life cycle of the type species of the genus, *Ph. oncorhynchus*, particularly the long time (about 3 years) of maturation in the definitive host, and also the presence of polynuclear esophageal glands.

Of the life cycles of species of Camallanata, the ontogeny of only 20 species has so far been studied. None of the species studied are strictly specific for their intermediate hosts or for their localization. The species

of this suborder develop (to third-stage larvae) in the body cavity of lower crustaceans: Cyclops, Diaptomus, and Branchiura.

This monograph on the Camallanata, the first and only in the literature intended for biologists and helminthologists in the medical and veterinarian field, will enable specialists to determine all species of Camallanata parasitizing in animals throughout the world.

K. I. Skrjabin

MORPHOLOGICAL AND ANATOMICAL DESCRIPTION OF CAMALLANATA

Form and size of the body

The form and size of the body of Camallanata vary markedly and cannot be used as typical characters of the suborder. In some groups the length of the body is not over 22–23 mm in males and 25–28 mm in females (superfamily Camallanoidea), while in others the body is very long and thin; for example, females of *Dracunculus medinensis* reach a length of 1.5 m (superfamily Dracunculoidea).

The body of Camallanata is of more or less uniform width most of its length, narrowing toward the ends. Sexual dimorphism is generally expressed in the difference in size between males and females, which is sometimes very marked (family Dracunculidae).

Cuticle

The cuticle of Camallanata is usually smooth and without any differentiations. Transverse striation is generally present and sometimes well developed.

Tornquist (1931) stated that in the Camallanidae the cuticle consists of six layers, which are clearly distinguishable at the caudal end. The forms which are characteristically localized in the inner parenchymatous organs, connective tissue, and blood vessels have sometimes more or less developed cuticular tubercles on the surface.

Rasheed (1963) distinguished the following types of cuticle in the family Philometridae (Figure 1):

1. The cuticle is smooth, the most common type of cuticle, present in species of most genera. It has a smooth surface without ornamentation or thickenings (Figure 1, a) (*Philometra* Costa, 1845).

2. The cuticle has convexities or swellings in some places, "tubercles" and "spines" (Figure 1, b), which may be scattered over the whole surface or are concentrated in some areas (*Philometroides* Yamaguti, 1935).

3. The cuticle has dense, shining convexities on the body: "pillars" and "cones" which are formed by the cortical, fibrillar, and basal layers of the cuticle (Figure 1, c–h); they vary in form and size: sometimes needle-shaped as in *Buckleyella* Rasheed, 1963, sometimes cone-shaped as in *Nilonema* Khalil, 1960.

In species of the genus *Tetanonema* from the vascular system of Cyclostomata cuticular tubercles are weakly developed.

The females of most species of Camallanata have three teatlike formations at the end of the tail; there are six of them in the females of *Spiroscamallanus xenopodis*. The larger the female, the less numerous are these formations, the largest specimens having two or one, or sometimes none at all. The same is observed in the infective larvae. Lateral wings are not always present.

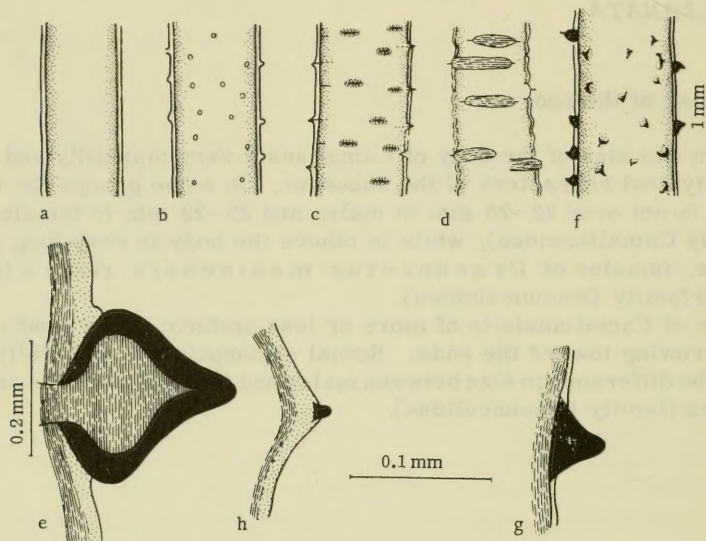


FIGURE 1. Types of cuticle in the Philometridae:

a — smooth (*Philometra* — general view); b — with "tubercles" and "spines" (*Philometroides* — general view); c — e — with "warts" and "rods" (c, d — *Buckleyella* — general view; e — part of cross section, enlarged); f — h — with "cones" (f — *Nilonema gymnarchi* — general view; g — *Nilonema senticosa*, magnified; h — same, *Nilonema gymnarchi*) (after Rasheed, 1963).

Hematophagous Camallanata are red during life; fixed specimens are usually whitish yellow or brownish.

Structure of the cephalic end

Chitwood and Wehr (1934) and Chitwood and Chitwood (1950) summarized the data on the structure of the cephalic end of nematodes, particularly of the Camallanata.

They noted that in the suborder Camallanata there are no ventrolateral papillae or lips, but there may be rudiments of lips or lateral valves; the latter are present in most species of the superfamily Camallanoidea. The mouth is hexagonal in the Procamallaninae. The outer ring consists of four papillae; the papillae of the inner ring are very small.

Species of the superfamily Dracunculoidea have neither lips nor valves; the round mouth is enclosed in a thin circumoral membrane, on the outside of which cuticularized protuberances may be present (*Dracunculus*, *Avioserpens*) or absent (*Philometra*, *Micropleura*) (Figure 2). The inner ring of papillae is well developed; the outer ring consists of eight papillae. In *Micropleura* and *Philometra* all the papillae are distinctly developed, while in *Dracunculus* and *Avioserpens* the median papillae of the outer ring are partly fused. In *Dracunculus* the interoventral and interodorsal papillae become fused in the female during development, but in the male the papillae maintain the normal arrangement. Species of *Dracunculidae* have a thickened cuticular shield which projects anteriorly, forming a circumoral protuberance, and it surrounds the anterior end of the esophagus posteriorly. The genus *Dracunculus* differs from *Avioserpens* in the presence of a cuticular ring around the mouth on the cephalic shield characteristic for both genera.

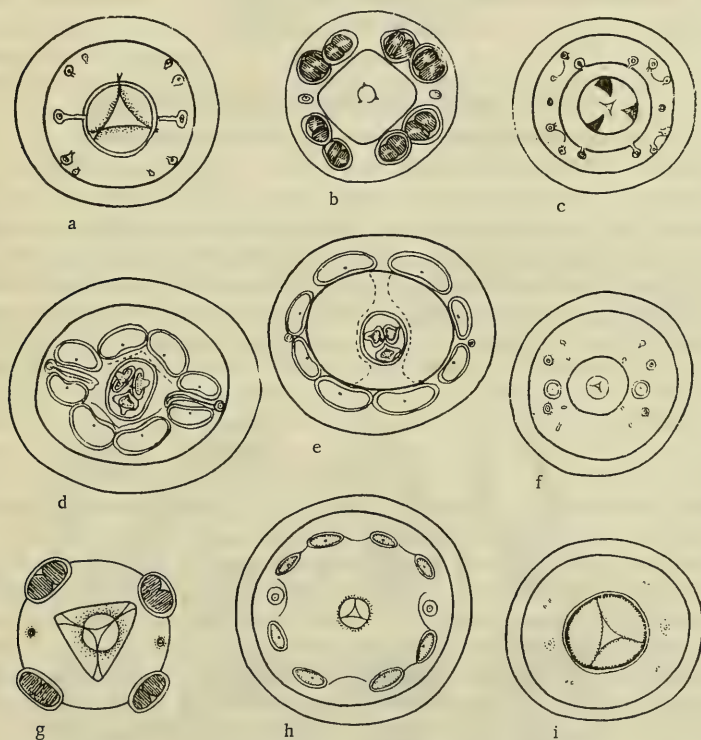


FIGURE 2. Arrangement of the cephalic papillae in the Philometridae (apical):

a — *Philometra* (*Philometra*); b — *Philometra* (*Ranjhinema*); c — *Philometra sydneyi* Rasheed, 1963; d, e — *Buckleyella buckleyi* Rasheed, 1963; f — *Nilonema senticosa* (Baylis, 1927); g — *Thwaitia* Rasheed, 1963; h — *Philometroides anguillae* (Ishii, 1916); i — *Philometra* (*Alinema*) (after Rasheed, 1963).

The superfamily Camallanoidea is characterized by a well-developed stoma in most forms and at least a distinct vestibule in others (Figures 3, 4). The superfamily Dracunculoidea has a rudimentary stoma. Amphids, 10 described for some genera of Camallanata, are situated near the lateral cephalic papillae; they are particularly well developed in the genera *Dracunculus* and *Avioserpens*.

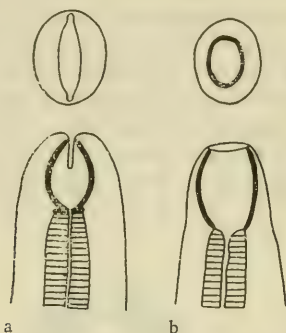


FIGURE 3. Structure of the buccal capsule of Camallanidae:

a - bivalvate (apical and ventral); b - entire (apical and ventral) (after Yeh, 1960).

The difficulty in the study of the cephalic end of species of *Philometridae* resulted in that about 30 species were described without mention of the cephalic papillae. In 1963, during a study of the cephalic end of *Philometridae* in lactophenol, Rasheed found that cephalic papillae are always present in this group. She did not find other structures on the cephalic end of *Philometridae*.

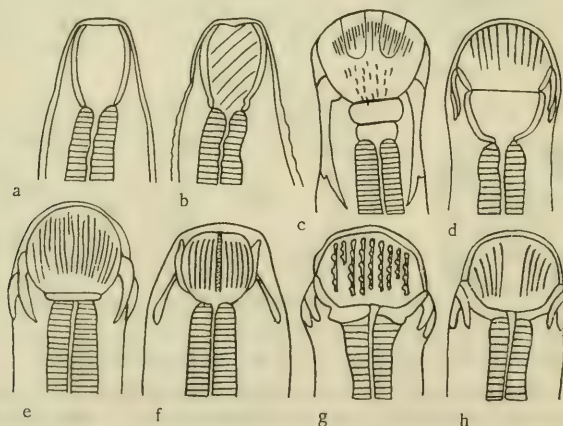


FIGURE 4. Structure of the cephalic end in the Camallanidae:

a - *Procammallanus*; b - *Spirocamallanus*; c - *Piscilania*; d - *Paracammallanus*; e - *Camallanus*; f - *Camallanides*; g - *Zeylanema*; h - *Serpinema* (after Yeh, 1960b).

The number, size, form, and structure of the papillae vary considerably. For example, the cephalic papillae are so large in some genera that they form lobelike structures (*Buckleyella* and *Thwaitia*). These papillae are strongly muscular; nerve endings are not recognizable. In other forms the papillae are very small, and only the nerve endings are recognizable; the cuticular processes surrounding them are very small (*Alinema*).

The cervical papillae are never very well developed in the Camallanata. They are situated near the nerve ring, slightly before or behind it. In the 11 genera *Avioserpens* and *Dracunculus* the cervical papillae are also situated slightly behind the nerve ring and are difficult to distinguish. The cervical papillae are not mentioned in descriptions of other genera.

Intestinal tract

The mouth is slitlike, rounded or triangular, and directed dorsoventrally.

The buccal capsule of Camallanata shows a great diversity of structure in the different genera and is an important character for their determination. Higher taxa differ markedly in this character.

The Camallanidae have a strongly developed chitinous armature of the buccal capsule and its adjacent parts. In the genus *Camallanus* the walls of the capsule form strong reddish brown "valves" with longitudinal ribs. Tornquist (1931) showed that there is no reason to consider these valves as a characteristic formation that would differentiate these species from others, as authors have done in the past. This is only a strong development of the walls of the buccal capsule, and not a differentiated morphological element. Such thickenings of the lateral walls of the buccal capsule are present also in other genera of Camallanidae and particularly well developed in the genus *Camallanides*.

Species of three genera of Camallanidae have a cuticular ring between the buccal capsule and the esophagus; other genera show characteristic trident formations on the dorsal and ventral side of the body. All these formations are yellow or reddish brown.

Chitwood and Wehr (1934) consider the genus *Procamallanus*, which has a hexagonal mouth and no cuticular "valves," as the most primitive genus of Camallanidae. As regards the morphology of the stoma in the Camallanata, the authors note that despite its distinctive structure, divisions may be found in species of Camallanidae which resemble the divisions of the stoma of other genera of this family. The primitive character of the genera of Procamallaninae is expressed in the absence of "valves" and in that the stoma, which is rounded in cross section and not dorsoventrally compressed, is usually less developed than in other genera of this subfamily. A prostoma and telostoma can be distinguished, although the various elements of the protorhabdion are not distinct. The stoma of the genera of Procamallaninae resembles in general that of the Thelaziidae (*Spirurata*). Chitwood and Wehr think that the stoma of *Paracamallanus*, in which a prorhabdion (from which the "valves" develop), mesorhabdion, and telorhabdion are distinctly developed, is the original type of the buccal section in genera of the subfamily Camallaninae.

The telostoma in the genus *Camallanus* is surrounded by a chitinous ring (or collar), which is homologous to the telorhabdion. Chitinous appendages (tridents) are developed at the base of the prorhabdion. In the genera *Camallanus* and *Paracamallanus* two pairs of winglike formations, lateral to the mouth, are present on the outside.

12 The stoma is not divided in the genus *Anguillicola*, for which Yamaguti (1935) established a separate family, and in the genus *Skrjabillanus* of the family *Skrjabillanidae* Schigin and Schigina, 1958. The present authors and V. A. Tikhomirova, who studied the morphology and biology of the family *Skrjabillanidae* and clarified the life cycle of *Agrachanus scardinii* and *Molnaria erythrophthalmi*, place these two families in the new superfamily *Anguillicoidea*. The stoma of the *Dracunculidae* is rudimentary.

The suborder *Camallanata* contains forms in which the esophageal glands are primarily mononuclear; forms with polynuclear glands apparently appeared secondarily (Chitwood and Chitwood, 1950).

The superfamily *Camallanoidea* is characterized by a relatively well-developed musculature and three esophageal glands, one of which is situated dorsally and the other two subventrally. The dorsal gland extends through both parts of the esophagus, and its duct opens before the nerve ring. The subventral glands are situated in the posterior part of the esophagus, and their ducts open into its anterior part. The nuclei of the glands are situated at the same distance from the anterior end, in the posterior part of the glandular part of the esophagus.

The family *Dracunculidae* has strongly developed esophageal glands, the nuclei of which are long and narrow. The ducts open in the region of the esophagus.

The esophagus of *Camallanata* was studied by Jägerskiöld (1909), Magath (1919b), Tornquist (1931), and Hsü (1933a). It is not of uniform structure in the different groups of this suborder. In the *Camallanidae* the anterior part is muscular and the posterior part glandular. The anterior part is slightly shorter than the posterior part. The posterior part projects slightly into the intestine. Magath (1919b) mentions three valve-like formations at the end of the esophagus. Tornquist (1931), who also studied *Serpinema microcephalus*, stated, however, that valves are absent at the end of the esophagus. *Serpinema microcephalus* has a divided esophagus. The dorsal opening of the gland is situated slightly behind the base of the stoma; the subventral openings are situated at the anterior end of the posterior part of the esophagus. There are 18 radial and six marginal nuclei in the anterior part of the esophagus. The radial nuclei are arranged in four groups: two groups of three nuclei before the opening of the dorsal gland and two groups of six nuclei behind it. The marginal nuclei form two groups, one near the opening of the dorsal gland and the other between the third and fourth radial group. The posterior part of the esophagus also has 18 radial nuclei in four groups and six marginal nuclei in two groups. The first group of six radial nuclei is situated near the anterior end of this part of the esophagus at the level of the openings of the subventral glands, the second group of six radial nuclei is situated slightly before the middle of this part of the esophagus, and the third and fourth groups of three radial nuclei are situated near the base of the esophagus. One marginal group is situated directly behind the openings of the subventral glands, the other near the third group of radial nuclei.

3 The esophagus of the Dracunculidae was studied by Jägerskiöld (1893), Strassen (1907), Mirza (1929), Hsü (1933b), and Yamaguti (1935). It may be cylindrical, as in *Micropleura*, club-shaped or barrel-shaped, as in *Philometra*, or divided into a short, narrow anterior muscular part and a long, wide posterior glandular part, as in *Philonema*, *Dracunculus*, and *Avioserpens*: in *Dracunculus* and *Avioserpens* the glandular part narrows at the nerve ring. The anterior part of the esophagus of *Dracunculus*, *Avioserpens*, and *Philometra* forms a hemispherical swelling; this is not the case in *Philonema* and *Micropleura*. In the genus *Philometra* the esophagus is usually widened around the mouth and has the form of a bulb; in some species the three lobes of the esophagus project from the mouth or become cuticularized and pointed, forming esophageal teeth. The lumen of the esophagus is usually wide in its anterior part, which in some species forms a cavity surrounded by the lobes of the esophagus. The esophagus of *Philonema* is cylindrical and is of almost the same width its whole length. The genus *Rumai* has a club-shaped esophagus; the anterior part is cylindrical, the posterior part gradually increases in width. In *Philometra parasiluri* the esophagus is entirely muscular. The other genera of Dracunculidae have either an esophagus divided into an anterior muscular and a posterior glandular part or glandular tissue situated in the dorsal part of the esophagus.

The radial and marginal nuclei in *Dracunculus*, *Avioserpens*, and *Micropleura* have the same arrangement as in *Camallanus*. All these nuclei also show a uniform arrangement relative to the openings of the esophageal glands. The region behind the narrowing at the nerve ring in *Dracunculus* and *Avioserpens* corresponds to the posterior part of the esophagus of *Camallanus*. The dorsal esophageal gland and its nucleus are very large. The fourth and fifth groups of radial nuclei in *Philometra* are divided into two subgroups, but the marginal and radial nuclei have the same arrangement as in *Dracunculus*; in the latter genus, however, the subventral glands are very much smaller. Yamaguti described the genus *Ichthyofilaria*, the esophagus of which has a posterior glandular appendage as in *Contracaecum*. However, no histological study of this structure has been made.

Chitwood and Chitwood (1950) stated that the genus *Philonema* shows an extreme development of the esophageal gland in the Dracunculoidea. This genus has a typical spiruroid-filarioid esophagus, and it is doubtful whether it should be placed in the suborder Camallanata. The three openings of the esophageal glands are situated in the posterior, markedly wider glandular part of the esophagus, and the esophageal glands are mononuclear. The radial nuclei in all six groups are distributed in groups of three, i. e., all six groups are subdivided. Since there are three groups of radial nuclei in the anterior muscular part of the esophagus, this part may be homologous to the anterior part of the esophagus in the Camallaninae; the position of the openings of the subventral glands support this view. The opening of the dorsal gland is displaced much farther posteriorly in these forms. Each esophageal gland contains several hundred nuclei of varying size which are often arranged in "constellations," a result of nuclear budding caused by gigantism. This may be analogous rather than homologous to the case of polynuclear glands in the Spiruridae. In the latter the many nuclei of the glands apparently developed by division as they are all of more or less the

same size. If *Philonema* developed independently, the gigantism of these glands in *Dracunculus* and *Philometra* may be correlated with the nonuniform nuclear division (amitosis?) in the glands of *Philonema*.

14 Hsü (1933b) described "simple tubular" glands in *Philometra* and *Dracunculus*, stating that other nematodes have "branched tubular" glands. It is easy to make a mistake during the examination of these structures, especially when the glands end in single or branched terminal lobules. For example, in *Dracunculus oesophagea* the subventral glands are complex ramified alveolar formations, while the dorsal gland is apparently a simple branched alveolar gland.

The intestine of *Camallanata* is usually a simple tube ending in an anus, which is obliterated in adult females of *Dracunculidae*.

Genitalia

Males. The male genitalia consist of a single testis, which passes into the vas deferens and ends in the ejaculatory duct, which opens into the cloaca. The elements of the copulatory apparatus vary considerably in structure in the different families.

The spicules are of different length in the *Camallanidae*. The left spicule is always shorter, with rounded section, and wings are absent. It is less wide than the right spicule. The right spicule has usually, but not always, wings, and the left wing is wider than the right.

The right spicule ends in a hook in *Camallanides*. Both spicules are pointed.

The species of the family *Dracunculidae* have thin spicules pointed at the distal end. They are of equal or nearly equal length. Spicules are absent in the superfamily *Anguilliculoidea*. A chitinized plate is present in some forms.

A gubernaculum is not present in all genera. It is nearly triangular in the *Camallanidae*. In the *Dracunculidae* the presence of a gubernaculum has been established in the genera *Dracunculus*, *Avioserpens*, *Philometra*, and *Micropleura*. A gubernaculum is absent in the *Anguilliculoidea*.

The caudal wings of males are never very large. They are best developed in the family *Camallanidae*, in which they are relatively narrow. Caudal wings are absent in the family *Dracunculidae* except in some species of the genus *Micropleura*, which have only a right wing which is partly interrupted. There are two liplike processes at the cloaca in the genus *Philometra*.

The genital papillae on the tail of males usually form two longitudinal subventral rows, some of the papillae being preanal, others adanal, and still others postanal. Pedunculate papillae are present in the *Camallanidae*, as these also have caudal wings; in other families there are indistinct sessile papillae. The arrangement of the caudal papillae in the genus *Dracunculus* is characteristic. The preanal papillae are arranged in two rows, often densely; these rows are situated anteriorly, close together; they then diverge, forming sides of an equilateral triangle, the base of which is the cloaca. The angle of divergence of the rows of papillae is 15 about 90° in *Dracunculus medinensis*, but it is acute in *D. oesophagea*. The first two pairs of postanal papillae also have a distinctive

arrangement. The first pair is situated close together, but the papillae of the second pair are more widely spaced than the distance from the papillae of the corresponding side of the right pairs. The caudal part has apparently become shorter during evolution, resulting in this arrangement of the papillae.

The caudal end of males of Camallanata may be moderately long, rounded, moderately pointed (Camallanidae), or cone-shaped (Dracunculus).

The caudal end has the form of a truncated cone in the genus *Philotmetra* (there may or may not be papillae on the caudal end). It is conical in the genus *Rumai*. The males of the genus *Philonema* have a long, thin tail which tapers to a point.

Females. The structure of the female genitalia shows marked differences in the different genera and families.

The species of the family Camallanidae have one anterior ovary. This is followed by the oviduct, which passes into the uterus, ovejector, and the vagina, which is lined with cuticle. The vulva is usually situated in the middle of the body, but it may be displaced slightly anteriorly or posteriorly. The vulva of the genus *Camallanus* has distinctly projecting lips, one of which may project more markedly. The vulva forms a tubelike appendage in the genus *Camallanides* which is slightly dorsoventrally compressed. It projects above the surface and is directed posteriorly. The posterior uterus is either bluntly rounded at the end or it ends in a rudimentary ovary.

In the genus *Dracunculus* the vulva is situated before the middle of the body only in young specimens; after fertilization it is closed by a plug of mucus and is eventually obliterated. The uterus is very large, saclike, and fills the body cavity in adults. There are two ovaries, which undergo reduction in adults. The female genitalia of the genus *Philotmetra* are of similar structure. All species of the suborder Camallanata are viviparous.

HISTORY OF STUDY OF THE CAMALLANATA

The suborder Camallanata was established by Chitwood in 1936, but in 1937 he proposed new names for some suborders of nematodes, including the Camallanata, which he renamed Camallanina (after Chitwood, 1937). Skrjabin and Shul'ts (1940) reinstated the original name, which we have also accepted here.

Chitwood included two superfamilies in the suborder Camallanata: Camallanoidea Travassos, 1920 and Dracunculoidea Cameron, 1934.

The original diagnosis of the suborder is as follows: Spirurida. Pseudolabia absent; lips also usually absent. Six rudimentary lips sometimes present. Stoma sometimes forming two lateral valves. Esophageal glands mononuclear, dorsal gland opening anterior to the third group of radial nuclei (Chitwood, 1937).

The superfamily Camallanoidea was established by Travassos in 1920, with the following families: Camallanidae Railliet and Henry, 1915, Cucullanidae Cobbold, 1864, and Dacnitoidea Travassos, 1920.

16 Baylis (1923a) did not consider the superfamily Camallanoidea and the family Dacnoididae sufficiently substantiated. He placed the families Camallanidae and Cucullanidae in the superfamily Spiruroidea, and did not consider them to be more closely related to each other than to other families of the superfamily. Yorke and Maplestone (1926) used the same arrangement. Superfamilies are not mentioned in the review of Baylis and Daubney which also appeared in 1926. The order Filarioidea is stated to include the families Filariidae, Philometridae (=Dracunculidae), Spiruridae, Camallanidae, Cucullanidae, and Gnathostomatidae.

Travassos' work was thus not corrected, and later authors did not consider the families Camallanidae and Cucullanidae as closely related. Tornquist (1931) published a monograph on these two families, in which he gave a detailed analysis of their history of study and systematics and carried out important morphological and histological studies.

Tornquist's work constitutes the culmination of the increasing tendency to dissociate the families Camallanidae and Cucullanidae. Tornquist gives the following points of similarity between the families: the same number of cephalic (oral, in his terminology) papillae, the structure of the nervous system, polymyarian musculature, the number of phagocytic organs, the position of the vulva, the composition of hosts, and the type of localization. However, he also gives a number of characters which differentiate these families: the difference in size between the sexes, the form of the cervical papillae, the number of cells of the excretory duct, the form of the posterior esophagus, the arrangement and structure of the esophageal glands, the length of the spicules, the mode of reproduction (the Camallanidae are viviparous, the Cucullanidae oviparous), and the presence (Camallanidae) or absence (Cucullanidae) of a caudal bursa. We have stressed the characters which, according to Tornquist, have the greatest systematic importance. As to the systematic position of the two families, Tornquist concluded that the Cucullanidae should be placed in the superfamily Strongyloidea Weinland, 1858. He suggests that the Camallanidae should be retained in the superfamily Spiruroidea Railliet and Henry, 1915. Tornquist's proposals were not accepted.

Chitwood and Wehr (1934) published a work in which the superfamily Camallanoidea is not mentioned, but he concluded that the Camallanidae and Cucullanidae may be connected through a more primitive form related to the Thelaziidae. In Chitwood's classification the superfamily Camallanoidea established by Travassos was re-instated and placed near the Dracunculoidea. The latter superfamily was first mentioned by Cameron (1934) and only the family Dracunculidae was originally included in it. The Dracunculoidea resemble the Camallanoidea in that they have mononuclear esophageal glands and the larvae have large pocket-shaped phasmids. The species of both superfamilies parasitize vertebrates in the adult stage and crustaceans in the larval stages.

17 In the "Key to Parasitic Nematodes," Volume IV (Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954) the family Cucullanidae Cobbold, 1864 was placed in the superfamily Camallanoidea Travassos, 1920, and it was considered, together with the superfamily Dracunculoidea Cameron, 1934, to belong to the suborder Callamanata Chitwood, 1936. The authors thought that a phylogenetic classification of the suborder Camallanata could not yet be constructed because of the absence of data on the development and morphology of many species of the group. They gave the following classification of the suborder:

- Suborder Camallanata Chitwood, 1936
 - Superfamily Camallanoidea Travassos, 1920
 - Family Camallanidae Railliet and Henry, 1915
 - Family Cucullanidae Cobbold, 1864
 - Subfamily Cucullaninae Yorke and Maplestone, 1926
 - Tribe Cucullaninea Sobolev, 1952
 - Tribe Dichelininea Sobolev, 1952
 - Subfamily Seuratinae Hall, 1916
 - Superfamily Dracunculoidea Cameron, 1934
 - Family Dracunculidae Leiper, 1912
 - Subfamily Dracunculinae Stiles, 1907
 - Subfamily Avioserpentinae Wehr and Chitwood, 1934
 - Subfamily Philometrinae Yamaguti, 1935
 - Subfamily Micropleurinae Baylis and Daubney, 1922
 - Family Tetanionematidae Skrjabin and Schikhobalova, 1948
 - Family Anguillicolidae Yamaguti, 1935

Yamaguti (1961) gave a classification in which the families Camallanidae Railliet and Henry, 1915 and Cucullanidae Cobbold, 1864 were considered as belonging to the order Spiruridea Diesing, 1861. In his view the family Camallanidae contains five and the Cucullanidae seven genera, in two sub-families.

For the other large group of nematodes which, according to the classification of Soviet authors (1954), are included in the suborder Camallanata and in the superfamily Dracunculoidea Cameron, 1934, Yamaguti established the new order Philometridea Yamaguti, 1961, in which he placed the families Philometridae, Anguillicolidae, Dracunculidae, Robertodolffusidae, and Crassicaudidae; for the family Tetanionematidae with one genus and one species he established the new order Tetanionematidea Yamaguti, 1961.

The classification of this group, according to Yamaguti, is thus as follows:

- Order Philometridea Yamaguti, 1961
 - Family Philometridae Baylis and Daubney, 1926
 - Subfamily Philometrinae Yamaguti, 1935
 - Genus *Philometra* Costa, 1845
 - Genus *Clavinema* Yamaguti, 1935
 - Genus *Coregonema* Bauer, 1946
 - Genus *Ichthyofilaria* Yamaguti, 1935
 - Genus *Philometroides* Yamaguti, 1935
 - Genus *Philonema* Kuitunen-Ekbaum, 1933
 - Family Anguillicolidae Yamaguti, 1935
 - Genus *Anguillicola* Yamaguti, 1935
 - Family Dracunculidae Leiper, 1912
 - Subfamily Dracunculinae Stiles, 1907
 - Genus *Dracunculus* (Linnaeus, 1758)
 - Subfamily Avioserpentinae Chitwood, 1935
 - Genus *Avioserpens* Wehr and Chitwood, 1934
 - Subfamily Chelonidracunculinae Yamaguti, 1961
 - Genus *Chelonidracunculus* Yamaguti, 1961
 - Subfamily Micropleurinae Baylis and Daubney, 1922
 - Genus *Micropleura* Linstow, 1906
 - Genus *Ophiodracunculus* Yamaguti, 1961

Family Robertodolffusidae Chabaud and Campana, 1950
 Genus Robertodolffusa Chabaud and Campana, 1950
 Family Crassicaudidae Skrjabin and Andreewa, 1934
 Genus Crassicauda Leiper and Atkinson, 1914
 Genus Placentonema Gubanov, 1951
 Order Tetanionematidea Yamaguti, 1961
 Family Tetanionematidae Skrjabin and Schikhobalova, 1948
 Genus Tetanionema Steiner, 1921

Ivashkin (1962) removed the family Cucullanidae Cobbold, 1864 from the superfamily Camallanoidea Travassos, 1920 and established for it the new superfamily Cucullanoidea Ivaschkin, 1962, including it in the suborder Camallanata Chitwood, 1936. Inglis (1967) placed the family Cucullanidae in the superfamily Seuratoidea Chabaud, Campana-Rouget, and Brygoo, 1959, suborder Ascaridata Skrjabin, 1915.

Skrjabin and Ivashkin (1968) established the suborder Cucullanata Skrjabin and Ivaschkin, 1968, with the superfamilies Cucullanoidea Ivaschkin, 1962 and Gnathostomatoidea Skrjabin and Ivaschkin, 1968.

Le-Van-Hoa and Fan-Ngok-Khue (1968), without mentioning the work of Ivashkin (1962) and Skrjabin and Ivashkin (1968a), established the superfamily Cucullanoidea, instead of the superfamily Seuratoidea.

Shigin and Shigina (1958) described a new nematode, *S. tincae*, from the renal serosa of tench, which they placed in the new genus *Skrjabillanus* and new family *Skrjabillanidae*. The authors placed the new family in the superfamily Dracunculoidea together with the family Anguillicolidae, in which they found a number of similar characters: a well developed stoma, absence of spicules, esophagus divided into a muscular and a glandular part, vivipary.

Sobolev (1952) placed the family Anguillicolidae in the superfamily Dracunculoidea, since it has to be considered as part of the suborder Camallanata in all characters. Chitwood (1937) placed in the subfamily Philometrinae the characteristic genus *Phlyctainophora* Steiner, 1921. Sobolev (1952) agreed with Chitwood and left it in this subfamily, but Roman (1960) established for this genus the new family *Phlyctainophoridae* Roman, 1960. In our opinion, the families Anguillicolidae Yamaguti, 1935, *Skrjabillanidae* Shigin and Shigina, 1958, *Phlyctainophoridae* Roman, 1960, and Tetanionematidae Skrjabin and Schikhobalova, 1948 should be removed from the superfamily Dracunculoidea and placed in the superfamily Anguilliculoidea Sobolev, Ivaschkin, Tichomirova, and Khromova.

Chitwood also thinks that the position of the genus *Philonema* Kuitunen-Ekbaum, 1933 in the classification of the suborder is not clear because there are mononuclear esophageal glands in its species. Sobolev (1952) placed this genus in the subfamily Philometrinae.

Because of the life cycle of the type species of this genus, *Philonema oncorhynchi*, particularly the long period of maturation in the definitive host (about 3 years), as well as the morphological characters of the species of the genus, we consider it justified to establish for the genus *Philonema* the new subfamily *Philoneminae*.

Skrjabin and Ivashkin (1968a) consider that the suborder Camallanata Chitwood, 1936 contains two superfamilies: Camallanoidea Travassos, 1920 with one family, Camallanidae Railliet and Henry, 1915, and the Dracunculoidea Cameron, 1934 with the families Dracunculidae Leiper, 1912, Anguillicolidae Yamaguti, 1935, and Tetanionematidae Skrjabin and Schikhobalova, 1948.

The present authors consider the Camallanata to contain three superfamilies: Camallanoidea Travassos, 1920 with one family, Camallanidae Railliet and Henry, 1915, Anguillicoloidea Sobolev, Ivaschkin, Tichomirova, and Khromova n. superfam. with the families Anguillicolidae Yamaguti, 1935, Phlyctainophoridae Roman, 1960, Skrjabillanidae Schigin and Schigina, 1958, and Tetanionematidae Skrjabin and Schikhobalova, 1948, and Dracunculioidea Cameron, 1934 with the families Dracunculidae Leiper, 1912 and Philometridae* Baylis and Daubney, 1926.

PHYLOGENETIC RELATIONSHIPS OF THE CAMALLANATA AND THEIR REFLECTION IN THE CLASSIFICATION OF THE SUBORDER

The superfamily Camallanoidea contains only one family, Camallanidae, in which the genera are clearly differentiated. Yeh (1960b) divided this family into two subfamilies, Camallaninae Yeh, 1960 and Procamallaninae Yeh, 1960, as follows: Camallaninae: Camallanus, Camallanides, Paracamallanus, Piscilania, Serpinema, Zeylanema; Procamallaninae: Procamallanus, Spirocamallanus.

The subfamily Procamallaninae is a homogeneous group. Olsen (1952b) divided the species into two groups according to the structure of the buccal capsule; the species of the subfamily were placed in a single genus. The most primitive genus is Procamallanus. The subfamily Camallaninae is also a fairly homogeneous group; its most primitive genus is Paracamallanus. Of great interest are the data of Moorthy (1938b) on the development of Zeylanema sweeti and the data of Kupriyanova (1954), Campana-Rouget (1961b), and Moravec (1969) on the development of Camallanus lacustris. The stoma of third-stage larvae is of the Paracamallanus type, in C. lacustris it becomes transformed into a camallanoid type during the third molt, and in Z. sweeti into a zeylanemoid type during the fourth molt. These data suggest that Paracamallanus** is the most ancient, primitive group in the Camallaninae. The structure of the buccal capsule of Camallanides is intermediate between the buccal organs of Procamallaninae and Camallaninae, but it still resembles the Camallaninae type because of the vertical ribs, lateral valves, and the almost round buccal capsule. All genera of Camallaninae, except Camallanides, have the distinct characters of the family. The genus Camallanides does not show marked differences from them, but its species are characterized by strongly developed lateral walls (valves) of the buccal capsule with marked reduction of the tridents, which are well developed in the other genera of Camallaninae (substitution of functions).

* Rasheed (1963) studied the literature and extensive material, analyzed and redistributed the species of the genera of the family Philometridae and gave more specific diagnoses of the genera. Her classification of the family Philometridae has been accepted here.

** Further evidence of the primitiveness of Paracamallanus is that the posterior part of the buccal capsule of adult specimens shows a formation which is found only in the larvae of other genera of Camallaninae.

We consider the superfamily Anguilliculoidea, with four families, as a transitional group which combines characters of such different superfamilies as the Camallanoidea and Dracunculoidea.

It is difficult to construct a classification of the Anguilliculoidea, since a number of the families contain monotypic, incompletely known genera.

In the superfamily Dracunculoidea Cameron, 1934 we retain the families Dracunculidae Leiper, 1912, with the subfamilies Dracunculinae Stiles, 1907, Avioserpentinae Wehr and Chitwood, 1934 emend. Chitwood, 1935, Micropleurinae Baylis and Daubney, 1922, and Philometridae Baylis and Daubney, 1926, with the subfamilies Philometrinae Yamaguti, 1935 and Philoneminae n. subfam.

BIOLOGICAL CHARACTERISTICS OF THE SUBORDER CAMALLANATA CHITWOOD, 1936

The suborder Camallanata contains three superfamilies: Camallanoidea Travassos, 1920, Anguilliculoidea n. superfam., and Dracunculoidea Cameron, 1934. The biology of the species of these superfamilies will be described separately.

Ontogenetic development in the superfamily Camallanoidea

Published data on the biology of the Camallanoidea are few and concern only species of the genera *Camallanus* Railliet and Henry, 1915, *Procamallanus* Olsen, 1952, and *Zeylanema* Yeh, 1960.

The development of *C. lacustris* (Zoega, 1776) was studied by Mechnikov (Mecznikow, 1866), who found two larvae of different stages of development in *Cyclops* sp. Leuckart (1876) thought that an intermediate host, *Cyclops*, has a part in the development of *C. lacustris*, and he described larvae at various stages. Linstow (1909) found larvae which he determined as *C. lacustris* in *Cyclops* and in *Asellus aquaticus*, and Leiper (1910a) found them in *Cyclops* sp.

The life cycle of this parasite was studied in detail by Kupriyanova (1954), Campana-Rouget (1961b), and Moravec (1969). *Camallanus lacustris* parasitizes in the intestine of freshwater fish. The females are viviparous, and the larvae are released into the water with the feces of the fish. Kupriyanova found that larvae discharged from a mature female into the water survive for 11–12 days at 9–10°C. The intermediate hosts of *C. lacustris* are *Mesocyclops leuckarti* and *Acanthocyclops viridis*. The first larval molt in the host was observed to take place after 24–48 hours at 19–21°. After the molt the old cuticle adheres closely to the new one and is therefore difficult to see. After molting, the larvae resemble larvae removed from females, except that the caudal end is more rounded. Their length is 0.445–0.446 mm and their maximum width 0.014–0.015 mm. The second molt takes place 5–6 days later. A distinct chitinous capsule appears at the cephalic end. The intestinal tract is divided into esophagus (muscular and glandular) and intestine.

21 The larvae are now 0.496–0.520 mm long and their maximum width is 0.017 mm. Kupriyanova found that the life cycle of *C. lacustris* involves an accessory host, possibly fish. The accessory host may be omitted from the cycle and is possibly a reservoir. Campana-Rouget did not mention Kupriyanova's studies but considers Leuckart's work as an accurate study of the life cycle, with respect to biological and morphological details. Campana-Rouget made another study of the development of this parasite in the intermediate host, with particular attention to the cephalic structures, which are important for the phylogeny of the group. According to her data, the intermediate hosts of *C. lacustris* are *Acanthocyclops viridis* and *Macrocyclops* sp. Larvae emerging from the female attach themselves to the substrate with the caudal end and survive for 3 days at 20–24°. Campana-Rouget observed the first molt in the intermediate host after 4–5 days. The second-stage larva has a buccal capsule, the nerve ring is situated 0.75 mm from the anterior end, and the esophagus becomes divided into a glandular and a muscular part. The larva is 0.700 mm long and 0.038 mm wide. The second molt takes place 8–10 days later. In the third-stage larva the buccal capsule is distinct and the esophagus is divided into two parts. The larva is now 0.880 mm long and 0.049 mm wide; the nerve ring is situated 0.095 mm from the anterior end and the anus 0.075 mm from the posterior end. The tail has the form of a truncated cone with three distinct denticles. Four or five days after the second molt the larvae coil into a spiral, but they do not become encapsulated. The larvae do not develop further in *Cyclops*, but they remain alive as long as the host.

As determined by Kupriyanova (1954), *C. truncatus* develops in the same intermediate hosts and has the same development as *C. lacustris*.

Li (1935) established that the development of *Spirocamallanus fulvidraconis* (= *Procamallanus fulvidraconis* Li, 1935) takes place in the body cavity of *Cyclops*. The first molt takes place 8–9 days after infection at room temperature; further development in the host was not observed.

According to Pereira et al. (1936), *Spirocamallanus cearensis* (= *Procamallanus cearensis* Pereira, Vianna, Diaz, and Azevedo, 1936) develops in *Diaptomus cearensis*, and is localized in the body cavity. The authors did not observe the molt of the larvae in the intermediate host, but according to differences in the morphological characters, they think that the first molt takes place about 3 days after entry into the host. After the molt the larvae are 0.66–0.77 mm long and 0.03–0.04 mm wide. The buccal capsule has the same structure as in adult specimens. The esophagus is divided into a muscular (0.14 mm long) and a glandular (0.12–0.13 mm long) part. The anus is situated 0.073 mm from the posterior end. The tail is short and ends in three or four denticles. These larvae are infective for the second intermediate host, a fish, in which the parasite completes the second molt but does not develop further than the third stage. The authors think that the definitive host possibly becomes infected directly when it eats the crustaceans, so that the life cycle of the parasite may continue without a second intermediate host. They assume that only one molt takes place in the crustacean, but there are probably two molts, as the first molt is difficult to observe because it takes place soon after the larva enters the intermediate host, and the differences between the first- and
22 second-stage larvae are very small.

The development of *Zeylanema sweeti* (= *Camallanus sweeti* Moorthy, 1937), a parasite of the intestine of *Ophicephalus gachua*, was studied in detail by Moorthy (1938b). The intermediate host of *Z. sweeti* is *Mesocyclops leuckarti*. The first molt is observed after 24–36 hours, the second after 5–7 days. The definitive host may become infected by eating *Mesocyclops*, but Moorthy thinks that in nature infection of the definitive host does not occur without a second intermediate host.

It appears from the above that the first-stage larvae of all Camallanoidea grow in the external environment and mature slowly in the intermediate host. The first molt takes place soon after infection of the crustacean, 24–48 hours later in *Camallanus lacustris* and *C. truncatus* and immediately after entry into the body cavity of *Mesocyclops* in *Zeylanema sweeti*. Some authors (Li, 1935; Pereira, et al., 1936) probably overlooked the first molt and thought that the development of *Camallanus* in the crustacean ceases at the second larval stage. The second-stage larvae are infective, in their view; however, the description of these larvae corresponds to that of third-stage larvae given by Moorthy (1938b). The third-stage larvae are infective and pass from the intermediate host directly into the definitive host, or they enter a reservoir host (small fish) and then enter the definitive host together with it.

Ontogenetic development in the superfamily Dracunculoidea

The superfamily Dracunculoidea also includes viviparous forms, and since the vulva of adult females is usually obliterated, the larvae emerge through a rupture of the uterus and cuticle when the female emerges from the definitive host into the water and becomes subjected to a different osmotic pressure. Before entering the intermediate host, the larvae of Dracunculoidea sometimes spend some time in the water and remain infective.

Fedchenko (1870), Fairley and Linston (1924), Isaev (1934a, b), and Craig and Faust (1937) established that *Dracunculus medinensis* develops in *Cyclops* for 12–15 days, but Manson (1893) and Leiper (1907) mentioned longer periods (to 5–6 weeks). Isaev observed two molts of *D. medinensis* in *Cyclops*. Craig and Faust maintain that the larvae of this species develop in the body cavity of *Cyclops* with one molt, possibly two.

Moorthy (1938a) gives a detailed description of the life cycle of *D. medinensis*. The larvae develop in the body cavity of *Mesocyclops leuckarti* and *M. hyalinus*. The first molt takes place after 5–7 days and the second 8–12 days after infection at 32–39° and after 8–10 and 13–36 days, respectively, at 12–21°. The second molt was found to take place before the cuticle of the first molt had been shed. Onabamiro (1954) recorded *Thermocyclops niserianus* as the intermediate host of *D. medinensis*.

- 23 Desportes (1938) showed that *Mesocyclops fuscus* is the intermediate host of *Dracunculus oesophagea*; the first larval molt takes place 10 days after infection.

Brackett (1938) described a new species from snakes, *Dracunculus ophidensis*, and established that *Cyclops viridis* is its intermediate host. The larva molts in *Cyclops* 12–15 days after infection and the second-stage larva becomes infective (the author apparently overlooked the first molt). If the high rate of infection of snakes and the relatively weak infection of *Cyclops* by *D. ophidensis* are compared, the author assumes that there should be an animal which "accumulates invasion." It was found by experiment that tadpoles may play the role of a carrier host, i. e. the parasitic larvae live in them for some time without further development.

Chabaud and Campana (1949) described a new species of Dracunculidae from birds: *Avioserpens galliardi*. The intermediate host was found to be a *Cyclops*, in which molting was observed 12 hours after infection. The authors evidently observed the second molt of *A. galliardi* and overlooked the first molt. According to their data, the cyclops contained a second-stage embryo 15 days after infection, the posterior end of which showed denticles which are characteristic for third-stage larvae.

An interesting study of the life cycle of *Avioserpens mosgovoyi*, a parasite of the subcutaneous tissue of *Fulica atra* and *Podiceps cristatus*, *P. ruficollis*, and *P. griseigena*, has been made by Supryaga (1965a, b, 1967a, 1969a). Females of *A. mosgovoyi*, passing into the outer environment through the ulcerated skin of the bird, discharge larvae into the water, where they are swallowed by *Cyclops*. After a few minutes, the larvae penetrate into the body cavity, where they develop to the third stage. At a water temperature of 25–30°, the first molt takes place 5–10 days after infection of the *Cyclops*; the second molt takes place 2–3 days after the first or 7–12 days after infection. After the first molt the larvae did not shed the larval sheath, and both sheaths were shed together after the second molt.

At a water temperature of 20–25° the first molt takes place after 16–19 days and the second after 19–26 days. When the water temperature is 15° or below, the larvae do not develop further and do not molt, but they are still capable of further development. When the infected *Cyclops* were transferred to an optimal temperature (24–26°), the larvae developed and became infective. In a case of superinvasion, when larvae of *A. mosgovoyi* of the first, second, or third stage were already present in the body cavity of the crustacean, the larvae of the first and the second infection became infective; however, it took much longer for the larvae of the second infection to develop. The same was observed when the *Cyclops* were infected with a large number of larvae of a particular stage (7–23 specimens). However, at such an intensity of infection, all the larvae became infective.

Supryaga (1967a, b) established that reservoir hosts, vertebrates (fish, Amphibia) and invertebrates (larvae of Odonata), may take part in the life cycle of *A. mosgovoyi*. The larvae grow slightly in size in the reservoir host but do not molt.

24 In the definitive host, third-stage larvae of *A. mosgovoyi* pass from the intestine into the body cavity. They then pass along the serosa of the internal organs and the mesentery to the air sacs and reach the subcutaneous tissue after 8–12 days.

The third molt takes place in the body cavity of the bird 4–5 days after infection; the fourth molt is completed in the subcutaneous tissue after 10 days in male larvae and after 13–14 days in female larvae.

Fertilization of females takes place 15–16 days after infection and the vulva then begins to be obliterated.

Fertilized females of *A. mosgovoyi* migrate into the submaxillary space of the bird, where a tumorlike formation appears after 18–20 days; ulcers are formed in this formation after 25–27 days.

Females of *A. mosgovoyi* begin to discharge larvae 28–29 days after infection. This continues for 10–11 days, and then the females begin to die. The life span of females of *A. mosgovoyi* in the definitive host is 39–44 days, that of males more than 9 months.

The life cycle of *Philometroides sanguinea* (= *Philometra sanguinea* Rudolphi, 1819), which parasitizes on the fins and in the body cavity of crucian carp, was studied by Nybelin (1931) and Wierzbicki (1960). Nybelin established that the intermediate hosts of this species are *Cyclops strenuus*, *Leptocyclops agilis*, and *Pachycyclops* sp. Wierzbicki observed that in May–June, when the water temperature is sufficiently high, mature females of *Ph. sanguinea* fall from the fins into the water where they split open and release a large number of larvae. The free-living larvae grow to some extent in the water. For example, on the first day after they emerged from the female they were 0.37–0.40 mm long and 0.010–0.013 mm wide; 5 days later they were 0.41–0.42 mm long and 0.013–0.016 mm wide. In the intermediate host the larvae penetrate into the body cavity, where they become infective after 4–5 days. Although the larvae sometimes live for as long as two months in the crustaceans, they remain infective only 8–10 days. The infective larvae enter the intestine together with the *Cyclops* and migrate under the peritoneum into the region of the kidneys, swim bladder, and gonads, where they grow and develop to maturity. After mating, the fertilized females leave the body cavity and pass to the fins, where they remain for some time. In spring or early summer, females containing larvae enter the water. The life cycle of *Ph. sanguinea* thus lasts a year. However, Wierzbicki found in experiments that the life cycle may be shortened if the ambient temperature is higher.

Vismanis (1964, 1966, 1967) studied the life cycle of *Philometroides lusiana* Visman, 1966, a parasite of carp, and found that the intermediate hosts of this species are Copepoda: *Macrocyclus albidus*, *Eucyclops serrulatus*, *Mesocyclops leuckarti*, *Cyclops strenuus*, *Acanthocyclops viridis*, and others.

25 Larval development in the intermediate host lasts 6–7 days. When they enter the intestine, the infected crustaceans are digested, and the larvae of *Philometroides* released penetrate through the wall of the intestine into the body cavity of the fish, where they develop further. After fertilization of the females, the males of *Ph. lusiana* settle in the wall of the swim bladder, where they apparently live until the host dies, while the females migrate to their permanent location, i.e. the scale pouches. They are about 4 mm long at this time. After they become attached under the scales, they grow rapidly. If the fish are infected in June, females of *Ph. lusiana* are 30 mm long at the beginning of August. During the winter, at low water temperatures (1–3°) the development of the nematodes ceases and begins again in spring, when the water temperature rises to 11°. At this time the females are 100–110 mm long and contain a large number of larvae which are 0.40–0.47 mm long. The larvae are released into the water at the end of May and in the first half of June at a water temperature of 15–20°. The life cycle of *Ph. lusiana* lasts about a year (from June to May–June the next year).

Kovaleva and Khromova (1967) made some observations of the biology of *Philometra globiceps* (Rudolphi, 1819), which parasitizes in the sex glands of *Uranoscopus scaber*. They found that the fish become infected after spawning in summer-autumn; further development of the parasites and of the genital products of the fish apparently proceed at the same time. When the fish reach stages IV—V of gonad maturity, the females contain a large number of fully formed larvae. In the spawning period of the fish (June, July) the walls of the uterus and cuticle of females of *Ph. globiceps* rupture, and numerous larvae are discharged into the water together with the genital products of the fish. The life cycle of *Ph. globiceps* lasts about one year.

Molnár (1966a, b, c) made some observations of the development of *Philometra ovata* (Zeder, 1803), a parasite of the body cavity of bream and roach, *Thwaitia abdominalis* (= *Philometra abdominalis* Nybelin, 1928), a parasite of the body cavity of minnow and gudgeon, and *Thwaitia rischta* (= *Philometra rischta* Skrjabin, 1917), a parasite of the opercula and subcutaneous tissue of the head of bleak. The author states that the fish become infected in June and July when they swallow infected *Cyclops*.

The females of Philometridae reach their maximum size only in May—June of the following year, and release a large number of larvae into the outer environment.

The above data show that the species of the subfamily Philometrinae, like the genera of the subfamily Dracunculinae, have an annual life cycle.

Ontogenetic development in the superfamily Anguilliculoidea

The life cycle has been studied only in the species *Agrachanus scardinii* and *Molnaria erythrophthalmi* of the family Skrjabillanidae.

Tikhomirova (published here the first time) showed that the development of these species takes place with an intermediate host which she determined as species of the genus *Argulus*: *A. foliaceus* and *A. coregoni*. In contrast to other Camallanata, the larvae of these species are not released into the outer environment. From the uterus they enter the tissue surrounding the parasites, and then they are carried by the bloodstream to the muscles and skin. Carp lice parasitizing on fish swallow the nematode larvae, which pass rapidly from the intestine into the body cavity and from there to the legs. The larvae grow and molt twice in the carp lice. The first molt
26 takes place after 4 days and the second after 8—9 days. The fish become infected when they feed on carp lice containing infective larvae.

According to the life cycle of *A. scardinii*, the species of the Anguilliculoidea are, in their biological characteristics, more specialized than the species of other superfamilies of the suborder Camallanata.

Twenty life cycles of species of Camallanata have been studied more or less completely. The species of the superfamilies Camallanoidea and Dracunculoidea studied do not show a strict specificity for their intermediate host or their localization. Their development to the third larval stage takes place in the body cavity of *Cyclops* and *Diaptomus*.

A free-living larval stage is characteristic for these species, but while growth of the larvae in the external environment is very distinct in the Camallanoidea, it is very minor in the Dracunculoidea (apparently in all species). The larvae of species of Anguillicoloidea are very delicate and die rapidly in the environment; from the definitive host they immediately enter the intermediate host, and from this again the definitive host.

Reservoir parasitism in the suborder Camallanata has been little studied so far. We think that in the Camallanoidea, the most primitive of the Spirurata, reservoir parasitism of type II (after Ivashkin, 1962) is present, i. e. the larvae grow in the reservoir host but do not undergo qualitative changes and do not molt. This type of reservoir parasitism is evidently present in *Spirocamallanus cearensis*, in which Pereira et al. (1936) observed the growth of larvae in small fish which are not the definitive hosts of this parasite. They think that the fish are a "superfluous intermediate host" in the life cycle of *S. cearensis*, although such an intermediate host has a valuable part in "concentrating the parasites." Reservoir parasitism was observed by Kupriyanova (1954) for *Camallanus lacustris* and *C. truncatus*.

Brackett (1938) stated that tadpoles may be experimental "carrier hosts" of *Dracunculus*. The above data of Supryaga on reservoir parasitism in *Avioserpens mosgovoyi* deserve special attention.

SUBORDER CAMALLANATA CHITWOOD, 1936

Diagnosis: Spirurida. Esophageal glands mononuclear, rarely with nuclear budding. Lips absent or rudimentary. Pseudolabia always absent. Stoma well developed or rudimentary. Esophagus divided into two parts: a muscular anterior and a glandular posterior part. Viviparous, development heteroecious. Intermediate hosts Crustacea. Larvae with large pocket-shaped phasmids.

Parasites of vertebrates, mainly fish.

Type superfamily: Camallanoidea Travassos, 1920.

Key to the superfamilies of the suborder Camallanata

- 1 (2). Stoma well developed or reduced. Males without spicules.
 superfamily **Anguilliculoidea** n. superfam.
 2 (1). Stoma well developed or reduced. Males with spicules.
 3 (4). Stoma well developed
 superfamily **Camallanoidea** Travassos, 1920 .
 4 (3). Stoma weakly developed
 superfamily **Dracunculoidea** Cameron, 1934 .

SUPERFAMILY *CAMALLANOIDEA* TRAVASSOS, 1920

Diagnosis. Camallanata. Eight cephalic papillae in the outer ring. Stoma well developed. Walls of stoma usually thick, sometimes forming chitinous "valves." Mouth slitlike, hexagonal. Lips absent or rudimentary. Pseudolabia absent. Anterior part of esophagus muscular, posterior part glandular. Spicules present. Gubernaculum present or absent. Vulva situated in middle of body. Viviparous.

Type family: Camallanidae Railliet and Henry, 1915.

FAMILY CAMALLANIDAE RAILLIET AND HENRY, 1915

Synonym: Cucullanidae Cobbold, 1884

Historical review

The family Camallanidae was established by Railliet and Henry in 1915 for the single genus *Camallanus*. Baylis and Daubney (1922) described a new species of this genus, *C. prashadi*, which differed from previously described species of the genus *Camallanus* in that the outer surface of the lateral walls of the buccal capsule shows thickenings of a reddish brown color separated by a longitudinal groove through the middle of the lateral wall. The authors considered this character as so important that they established the new genus *Camallanides* Baylis and Daubney, 1922. Yorke and Maplestone (1926) stated that
28 the buccal capsule of *C. cyathopharynx* Baylis, 1923 is divided into an anterior and a posterior part of almost equal size. As such a division of the buccal capsule is not present in other species of the genus, the authors established because of this character the new genus *Paracamallanus* Yorke and Maplestone, 1926, which they placed in the family Camallanidae together with the genera *Camallanus*, *Camallanides*, and *Procamallanus*.

After a study of the buccal capsule in species of the genus *Procamallanus* (which at that time contained 24 species), Olsen (1952b) placed the species of this genus in two genera: *Procamallanus* and *Spirocamallanus*. Olsen placed the species in which the inner surface of the buccal capsule was smooth in the first genus, and the species in which this surface showed spiral thickenings in the second genus.

Ali (1956) described the new species *C. singhi*, and because of the absence of "tridents or rods" established for it the genus *Neocamallanus* Ali, 1956.

Yeh (1960b, c) used the structure of the buccal capsule and spicules and the host composition of the forms of *Camallanus* as a basis for establishing four genera: *Camallanus* (Railliet and Henry, 1915) Yeh, 1960, *Piscilania* Yeh, 1960, *Serpinema* Yeh, 1960, and *Zeylanema* Yeh, 1960. He considered the genus *Neocamallanus* Ali, 1956 as a synonym of the genus *Camallanus*. Since the genera *Camallanus*, *Camallanides*, *Paracamallanus*, and *Piscilania* have a buccal capsule consisting of two lateral valves, while in the species of the genera *Procamallanus* and *Spirocamallanus* the buccal capsule is entire and tridents are always absent, Yeh placed these groups of genera in two subfamilies, *Camallaninae* and *Procamallaninae* of the family Camallanidae.

Chakravarty and Majumdar (1960) published a communication on the classification of nematodes of the family Camallanidae, in which they divided the family into two subfamilies: *Camallaninae* and *Neocamallaninae*. The

first subfamily contains the genera in which there is a pair of buccal valves and tridents are present or absent (Camallanus, Camallanides, and Paracamallanus) and the second the genera with an entire buccal capsule and without tridents (Procamallanus and Indocamallanus (= Neocamallanus)).*

Thus, Yeh and Chakravarty et al. divided the family Camallanidae into two subfamilies on the basis of the same characters, but since Yeh's work was published first, the name Neocamallaninae Chakravarty and Majumdar, 1960 should be considered as a synonym of Procamallaninae Yeh, 1960.

The family Camallanidae has the following composition:

Family Camallanidae Railliet and Henry, 1915

Subfamily Camallaninae Yeh, 1960

Genus Camallanus (Railliet and Henry, 1915) Yeh, 1960

Genus Camallanides Baylis and Daubney, 1922

Genus Paracamallanus Yorke and Maplestone, 1926

Genus Piscilania Yeh, 1960

Genus Serpinema Yeh, 1960

Genus Zeylanema Yeh, 1960

Subfamily Procamallaninae Yeh, 1960

Genus Procamallanus Yeh, 1960

Genus Spirocamallanus Olsen, 1922

Diagnosis. Camallanoidea. Mouth dorsoventral, slitlike or hexagonal. Lips absent or rudimentary. Pseudolabia absent. Outer ring of cephalic papillae consisting of four large and four rudimentary papillae; inner ring formed by six very small papillae. Stoma strongly chitinated, either laterally compressed, forming cuticular lateral "valves", or barrel-shaped (Procamallanus). Esophagus divided into a muscular anterior and a glandular posterior part.

The males have caudal wings and pedunculate papillae. Spicules different. Gubernaculum present or absent. Vulva situated in middle of body. Viviparous.

Type subfamily: Camallaninae Yeh, 1960.

Key to the subfamilies of the family Camallanidae

- 1 (2). Buccal capsule consisting of two lateral valves. Camallaninae Yeh, 1960.
- 2 (1). Buccal capsule entire Procamallaninae Yeh, 1960.

* The genus Neocamallanus was established by Chakravarty, Majumdar, and Sain together with the record of a new species, heteropneusti, the description of which was published in 1961. The authors probably did not know that the name Neocamallanus was preoccupied by Ali (1956), and therefore published a note in 1963 on the change of the name Neocamallanus to Indocamallanus, with the single species I. heteropneusti Chakravarty, Majumdar, and Sain, 1961.

SUBFAMILY CAMALLANINAE YEH, 1960

Diagnosis. Camallanidae. Buccal capsule with lateral valves, mouth slitlike, tridents present or absent.

Type genus: *Camallanus* (Railliet and Henry, 1915).

Key to the genera of the subfamily Camallaninae

- 1 (2). Buccal capsule divided into almost equal anterior and posterior parts *Paracamallanus* Yorke and Maplestone, 1926.
- 2 (1). Buccal capsule without a posterior part or this markedly smaller than the anterior part (3).
- 3 (4). Buccal valves with deep lateral grooves, tridents replaced by rodlike formations *Camallanides* Baylis and Daubney, 1922.
- 4 (3). Buccal valves without lateral grooves (5).
- 5 (8). Buccal capsule with longitudinal thickenings forming teeth *Zeylanema* Yeh, 1960.
- 6 (7). Longitudinal thickenings without armature (7).
- 7 (6). Buccal capsule with short thickenings anteriorly and spines posteriorly *Piscilania* Yeh, 1960.
- 8 (5). Buccal capsule with smooth, undivided thickenings (9).
- 9 (10). Buccal thickenings divided laterally into a dorsal and a ventral group *Serpinema* Yeh, 1960.
- 10 (9). Buccal thickenings in one lateral group. *Camallanus* (Railliet and Henry, 1915).

Genus *Camallanus* (Railliet and Henry, 1915) Yeh, 1960

Synonyms: *Cucullanus* Müller, 1777 (in part); *Neocamallanus* Ali, 1956

Historical review

30 The type of species of this genus, *Camallanus lacustris*, was mentioned by Müller (1777) in his study of the animals of Denmark and Norway. However, this parasite was known earlier. There are data (Skrjabin et al., 1954) that Leeuwenhoek had observed it; it was also mentioned by Pallas (1781), who stated that he found this form already in 1759.

Müller (1799a, b) placed this species in the genus *Cucullanus*, which he established in 1777. The generic name is derived from the word *cucullus*, a type of headdress. The choice of this name was apparently suggested by the characteristic buccal capsule of the species of this genus. However, Müller placed in this genus true species of *Cucullanus* and species of the genus *Camallanus* (in its present definition).

Dujardin (1845) concluded that the genus is heterogenous. He placed in the genus *Cucullanus* the species with a red coloration in life, lateral valves of the buccal capsule, caudal wings in males, and a vulva situated before the middle of the body.

This was wrong according to the rules of priority since the type of the genus *Cucullanus* described by Müller in 1777 did not correspond to the characters indicated. Railliet and Henry (1915), using the name *Cucullanus* in accordance with the characteristics of the originally described species, established the genus *Camallanus*. Railliet and Henry, 1915 for the species which Dujardin had wrongly placed in *Cucullanus*.

The original diagnosis of the genus *Camallanus* mentioned a character noted previously by Dujardin, i. e. the presence of chitinous valves forming the buccal capsule. In the diagnosis of the genus given by Yorke and Maplestone (1926) it is stated that the buccal capsule consists of two lateral chitinous valves ... Gnedina and Savina (1930) studied the type species and also mentioned that the buccal capsule consists of two valves. Tornquist (1931) stated that it is wrong to speak of valves in this case. He wrote that the genus shows a laterally compressed buccal capsule, not valves, and he does not mention valves in the diagnosis of the genus in his monograph. Tornquist is correct, since there is no reason to introduce a new morphological term which would differentiate the genus from all other nematodes and would give a wrong picture of the buccal capsule.

The genus *Camallanus* originally contained nine species. Baylis (1923a,b) transferred the species *Camallanus laeviconchus* (Wedl, 1862) to the genus *Procamallanus*, making it the type species of the new genus. In addition to an increase of the number of species because of description of new ones, a critical review of the genus was given. Chitwood (1932) made numerous species mostly described by MacCallum (1918) and Magath (1919a,b) synonyms of *C. microcephalus* Dujardin. No further revisions of the genus were made after 1932, although the number of its species increased rapidly.

Tornquist raised the question of the heterogeneity of the genus *Camallanus*. He stated that the species could be divided into two groups, one containing parasites of fish and the other parasites of Chelonia.

In assessing the taxonomic importance of the characters mentioned by Tornquist, we must admit that they are not of equal value. Since the publication of Tornquist, many species of this genus have been described and the life cycles of some species have been studied, so that the problem of the heterogeneity of the genus *Camallanus* is now much more complicated. Tornquist did not draw any systematic conclusions from his study of the differences between the parasites of fish and Chelonia.

Yeh (1960b) made a study of the structure of the buccal capsule in the species of the genus *Camallanus* and noted that the strongly sclerotized buccal capsule is of constant form and slow evolution in this genus. On the basis of the structure of the inner longitudinal thickenings: smooth in the genus *Camallanus*, consisting of two groups in the genus *Serpinema*, or armed in the genus *Zeylanema*, and also taking into account the structure of the spicules and the group of hosts, he established four genera: *Camallanus* (Railliet and Henry, 1915) Yeh, 1960, *Piscilania* Yeh, 1960, *Serpinema* Yeh, 1960, and *Zeylanema* Yeh, 1960.

Yeh made the genus *Neocamallanus* Ali, 1956 a synonym of the genus *Camallanus*. Ali considered his genus *Neocamallanus* as closely related to the genus *Camallanus*, from which it is distinguished only by the absence of tridents or rods. Yeh, in his diagnosis of the genus *Camallanus*, stated that tridents are present or absent.

Diagnosis of the genus: Camallaninae. Buccal capsule with parallel inner thickenings; tridents present or absent; spicules almost equal. Parasites of fish and amphibians.

Type species: *Camallanus lacustris* (Zoega, 1776) Railliet and Henry, 1915.

Camallanus lacustris (Zoega, 1776) (Figures 5–10)

Synonyms: *Echinorhynchus lacustris* Zoega, 1776; *Cucullanus lacustris* (Zoega, 1776) Müller, 1779; *Cucullanus elegans* Zeder, 1800; *Cucullanus coronatus* Zeder, 1800; *Cucullanus papillosus* Zeder, 1800; *Cucullanus armatus* Zeder, 1800; *Cucullanus anguillae* Schrank, 1788; *Cucullanus viviparus* Bloch, 1782 nec Linstow, 1906; *Cucullanus luciopercae* Schrank, 1788; *Cucullanus percae* Schrank, 1788; *Cucullanus cernuae* Gmelin, 1790; *Cucullanus lucii* Viborg, 1795; *Cucullanus alatus* Rudolphi, 1802; *Cucullanus tincae* Rudolphi, 1819, larvae; *Oxyuris velocissima* Nordmann, 1832 (?); *Ascaris velocissima* Diesing, 1851

Hosts: definitive — *Perca fluviatilis*, *Acerina cernua*, *Coregonus lavaretus*, *Coregonus peled*, *Osmerus eperlanus*, *Esox lucius*, *Leuciscus cephalus*, *Leuciscus idus*, *Aspius aspius*, *Chalcalburnus chalcoides*, *Abramis brama*, *Pelecus cultratus*, *Tinca tinca*, *Schizothorax pseudaksaiensis*, *Silurus glanis*, *Anguilla anguilla*, *Lota lota*, *Gobius kessleri*, *Pleuronectes flesus trachurus*, *Pungitius pungitius*, *Gasterosteus aculeatus*; intermediate hosts *Cyclops*, larvae of *Agrion*, *Asellus aquaticus*.

Localization: intestine and pyloric caeca.

Distribution: Europe, Asia, North America.

Description (after Gnedina and Savina, 1930). Body wider anteriorly and narrower posteriorly. Buccal capsule consisting of two bright yellow valves demarcating the slitlike mouth. Inner surface of valves with a varying number of longitudinal ribs. Each valve has an oval chitinous ornamentation on the anterior margin of the outer surface.

In apical view of the cephalic end it appears that at the points where the valves are connected there is a pair of cephalic papillae on the dorsal side and another pair on the ventral side. The posterior margin of the valves is surrounded by a chitinous ring-shaped formation and has chitinous tridents on the dorsal and ventral surface. The muscular part of the esophagus forms a club-shaped widening at the connection with the glandular part.

Male. Length 3.655–5.46 mm, width 0.153–0.221 mm. Cephalic end with a bright yellow buccal capsule, height of valves 0.106–0.27 mm, width 0.132–0.170 mm. Length of tridents: lateral branch 0.061 mm, median branch 0.069 mm. The esophagus consists of two parts: a muscular part 0.440 mm long and a glandular part 0.535 mm long. Cervical papillae situated 0.286 mm from cephalic end. Nerve ring and excretory pore situated 0.185 and 0.265 mm, respectively, from the cephalic end.

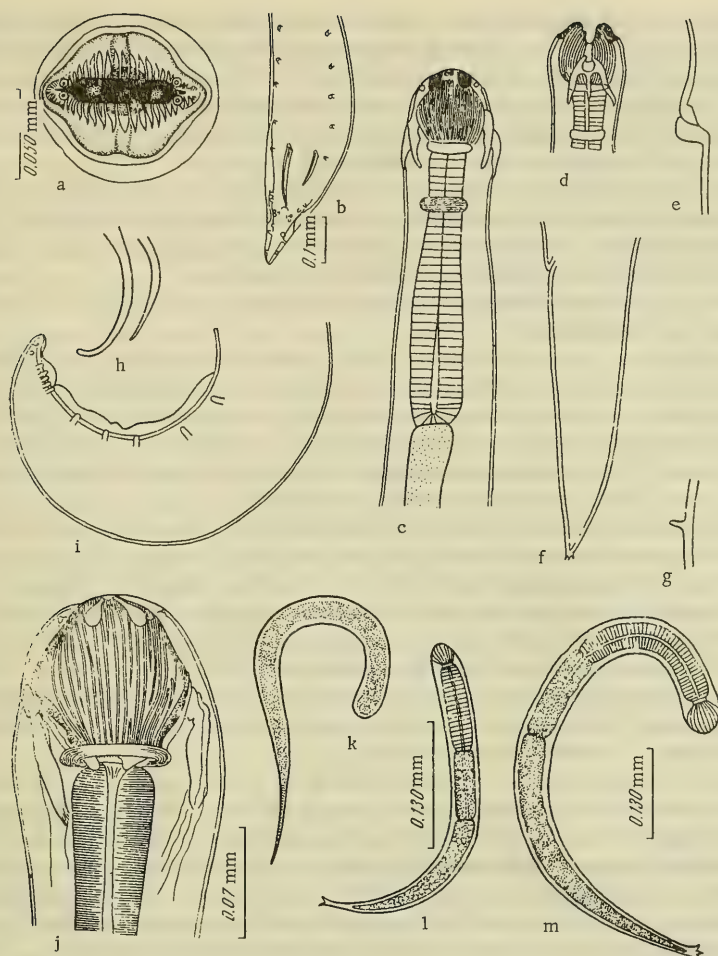


FIGURE 5. *Camallanus lacustris* (Zoega, 1776):

a - cephalic end, apical; b - caudal end of male, ventral; c - anterior end, lateral; d - cephalic end; e - region of vulva, lateral; f - caudal end of female, lateral; g - process of cuticle; h - spicules; i - caudal end of male, lateral; j - cephalic end, lateral; k - larva taken from adult female, lateral; l - larva after second molt, lateral; m - larva on the 37th day of development in a fish (a, b - after Gnedina and Savina, 1930; c - i - after Tornquist, 1931; j - after Sobolev, original; k - m - after Kupriyanova, 1954).

The caudal end is spirally twisted and has wings; there are 13 pairs of papillae, 7 pairs preanal and 6 pairs postanal.

The pedunculate preanal papillae are arranged symmetrically. The post-anal papillae are arranged as follows: the first three pairs are situated some distance from each other, while the second three pairs form two groups of three papillae near the anus.

The spicules have a slightly widened proximal end and then become gradually narrower. Length of larger spicule 0.133–0.145 mm, of smaller spicule 0.108–0.113 mm. Gubernaculum absent.

Female. Length 6.187 mm, width 0.244 mm. Height of valves of buccal capsule 0.208 mm, width 0.143 mm. The valves bear 25 longitudinal ribs. Length of tridents: lateral branch 0.193 mm, median branch 0.101 mm. Length of esophagus (muscular and glandular part) 1.404 mm. The nerve ring surrounds the esophagus 0.318 mm from the cephalic end; the excretory pore opens 0.291 mm from the cephalic end.

The vulva, which forms a slit, is covered by an oval thickening of the cuticle; it is situated 3.75 mm from the cephalic end. Anus situated 0.424 mm from the caudal end. Width of body in the anal region 0.106 mm. The caudal end ends in a point and has two subterminal papillae.

Larvae. Length of body 0.587 mm, length of esophagus 0.130 mm, its width at the end 0.020 mm.

Description (after Wysocka, 1965). Cephalic end with a yellow-red-dish brown, laterally flattened buccal capsule. Inner surface of capsule with 25 parallel ribs. A pair of winglike oval formations is present on the outside of the mouth. There is a cuticular ring between the buccal capsule and the esophagus. The esophagus consists of a short muscular and a long glandular part. Both parts are wider proximally.

Male. Length 4.1–4.5 mm, width 0.16–0.19 mm. Two cuticular tridents on the ventral and dorsal side of the buccal capsule. Length of tridents: lateral branch 0.083–0.096 mm, median branch 0.064 mm. Size of buccal capsule 0.096–0.102 mm (outer part) and 0.080–0.096 mm (inner part); width of capsule 0.077 mm. Length of short muscular part of esophagus 0.385–0.398 mm, of long glandular part 0.482–0.546 mm. Tail with relatively narrow caudal wings and 7 pairs of precloacal and 5 pairs of postcloacal papillae. Spicules of different length, 0.123–0.139 and 0.096–0.108 mm long. Gubernaculum absent.

34 Female. Length 5.5–11 mm, width 0.19–0.32 mm. Size of buccal capsule 0.128–0.141 mm (outer part) and 0.122–0.128 mm (inner part), width 0.096–0.115 mm. Size of tridents: lateral branch 0.101–0.122 mm, median branch 0.064–0.096 mm. Length of muscular part of esophagus 0.482–0.643 mm, of glandular part 0.739–0.868 mm. Genital pore situated in the middle of the body. Three or more teatlike formations are sometimes present on the tail. Size of embryonic spheres 0.028–0.032 mm. Viviparous. Larvae 0.442–0.445 mm long and 0.013–0.014 mm wide.

Description (after Mészáros, 1967). Buccal capsule yellowish-red-dish brown, chitinized, ribbed. The usual number of ribs is 25. The sides of the buccal capsule bear a tridentlike chitinized process, which does not reach halfway between buccal capsule and nerve ring. The esophagus consists of a shorter muscular and a longer glandular part.

Male. Length 3–4.2 mm, width 0.12–0.17 mm. Length of buccal capsule 0.094–0.105 mm. Esophagus divided into two parts, anterior part 0.373–0.380 mm long and posterior part 0.46–0.76 mm long.

Caudal end with narrow wings and 7 pairs of precloacal and 5 pairs of postcloacal papillae. Spicules 0.09–0.11 and 0.19–0.26 mm long. Gubernaculum absent.

Female. Length 5.2–7.4 mm, width 0.19–0.26 mm. Size of buccal capsule 0.10–0.142 mm. Esophagus divided into two parts, anterior part 0.48–0.52 mm long, posterior part 0.70–0.81 mm long.

Vulva situated in middle of body or slightly behind it. Viviparous. Larvae 0.39–0.43 mm long.

Description (after Moravec, 1969). Adults reddish to reddish brown. Cuticle dense, with moderate transverse striation. Mouth formed by a large reddish brown buccal capsule, which is strongly pseudochitinized and consists of two lateral valves with longitudinal ribs on the inner side. Number of ribs 18–20. Pseudochitinized round plates are present on the anterior margin of the valves. A strong pseudochitinized ring at the base of the capsule. The dorsal and ventral side of the buccal capsule are supported by tridents, which are much shorter than the capsule. Mouth slitlike, surrounded by four oral papillae, two of which are situated dorsolaterally and two ventrolaterally. Two small cervical papillae are situated immediately behind the nerve ring. Esophagus divided into a muscular anterior part and a glandular posterior part. The anterior part is slightly shorter. Intestine straight, wide, reddish brown.

Male. Length 2.285–4.038 mm, width 0.093–0.149 mm. Depth of buccal capsule 0.084–0.108 mm, width 0.075–0.093 mm. Length of tridents 0.051–0.090 mm. Length of muscular part of esophagus 0.299–0.530 mm, of glandular part 0.288–0.557 mm. Nerve ring situated 0.15–0.204 mm and cervical papillae 0.300 mm from the cephalic end.

35 The tail is conical, curved ventrally, and has narrow caudal wings. It is 0.087–0.108 mm long. There are two thin, simple spicules of different length. Shorter spicule 0.063–0.105 mm long, longer spicule 0.111–0.150 mm. The proximal ends of the spicules are slightly widened. Ventral side of tail with 7 pairs of precloacal and 6 pairs of postcloacal pedunculate papillae. The last two pairs of precloacal papillae are situated close together, and the last precloacal pair is displaced slightly toward the midline. The first three pairs of postcloacal papillae are situated close together, and the second pair is markedly displaced toward the midline. The last pair of postcloacal papillae is not very distinct.

Female. Length 3.617–7.080 mm, width 0.163–0.285 mm. Depth of buccal capsule 0.117–0.165 mm, width 0.126–0.156 mm. Length of tridents 0.078–0.135 mm. Length of muscular part of intestine 0.421–0.612 mm, of glandular part 0.530–0.761 mm. Nerve ring situated 0.231–0.312 mm, cervical papillae 0.326 mm from the cephalic end.

Vulva situated in middle of body, 1.523–2.545 mm from the cephalic end; it has two markedly raised lips. Vagina short, directed posteriorly. Uterus amphidelphic, occupying almost the entire body cavity when filled with developed larvae: it extends anteriorly to the nerve ring and posteriorly almost to the end of the tail. Tail relatively long, 0.204–0.462 mm, conical, ending in three rudimentary processes.

The development of *C. lacustris* was studied by Mecznirow (1866), who found two larvae of different stages of development in *Cyclops* sp. Leuckart (1876) studied the biological and morphological characters of *C. lacustris* larvae at various stages of development and showed that one intermediate host, *Cyclops* or larvae of *Agrion*, takes part in the life cycle, but the larvae do not develop in *Agrion*. Linstow (1909) found larvae of nematodes which he determined as *C. lacustris* in *Cyclops* and *Asellus aquaticus*, and Leiper (1910a) found larvae in *Cyclops* sp. Lyaiman (1934, 1949) mentions that the larvae of *C. lacustris* live in *Cyclops* and *Asellus aquaticus*.

The life cycle of the species was also studied by Kupriyanova (1954), Campana-Rouget (1961b, c), and Moravec (1969).

The females of *C. lacustris* are viviparous. Larvae discharged into the water with the feces of fish have the following measurements: length 0.442–0.443 mm, width 0.013–0.014 mm (after Kupriyanova, 1954); length 0.470–0.580 mm, width 0.020–0.030 mm (after Campana-Rouget, 1961c). The larvae are colorless, and the cephalic end does not yet have a chitinous buccal capsule; lips or papillae cannot be distinguished, except a small dorsal cuticular swelling which apparently represents a cephalic "tooth." The tail is long and pointed. In a larva 0.580 mm long Campana-Rouget found an undivided esophagus 0.097 mm long and the tail was 0.170 mm long; the nerve ring may be situated 0.030 mm from the cephalic end. Moravec gives a length of 0.468–0.505 mm, width 0.015–0.018 mm, length of esophagus 0.084–0.111 mm, length of tail 0.174–0.180 mm. Larvae emerging from the uterus are almost colorless; the body is thin, and the tail is pointed. The cuticle is thick, with relatively dense transverse striation which begins behind the cephalic end. On the dorsal side of the cephalic end the cuticle forms a relatively wide denticulate process. For some time (11–12 days at 9–10°, according to Kupriyanova, 3 days at 20–24°, according to Campana-
36 Rouget, or to 80 days at 7°, according to Moravec) the larvae live in the water, attached to the substrate by the caudal end.

About 40 minutes after *Cyclops* has swallowed larvae, these pass from the intestine into the body cavity, where they preserve their activity, increase in size, and become thicker, reaching a length of 0.605 mm and a width of 0.032 mm after 72 hours (Campana-Rouget, 1961b). Moravec also mentions that the larvae remain highly mobile and frequently change their localization in the intermediate host. From the time they penetrate into the body cavity until they molt, the larvae undergo few morphological changes except in size. In the first-stage larva the buccal capsule is a short, thin tube. The esophagus is not yet divided into a muscular and a glandular part. It is completely muscular, cylindrical, slightly wider at the posterior end; this wider part is formed by three elongate cells with large nuclei. The nerve ring and excretory pore are not recognizable. The intestine is straight, and rectal glandular cells are present. The first larval molt in the body cavity of *Cyclops* was observed by Kupriyanova (at 18–21°) after 24–48 hours, and by Campana-Rouget and Moravec after 4–5 days. The old cuticle is very thin and adheres closely to the new one, so that they cannot always be distinguished.

The second-stage larvae resemble the first-stage larvae in general. The esophagus is still not divided, but there is a swelling at the presumed place of division at the beginning of its posterior half; the intestine is at first transparent and then becomes reddish; the pharynx is surrounded by chitinized crescents. Kupriyanova gives the length of second-stage larvae as 0.445–0.446 mm and width 0.014–0.015 mm, and Campana-Rouget 0.700 and 0.038 mm, respectively, length of esophagus 0.192 mm, and distance of nerve ring from cephalic end 0.075 mm.

Six days after the larvae have entered *Cyclops*, the intestine becomes more orange. The larvae increase slightly in size.

Moravec notes that on the 8th day in *Cyclops* the larvae become less mobile and more rounded. The cephalic end widens and the developing buccal capsule also becomes markedly wider, exerting considerable pressure on the surrounding tissues. With the increase of pseudochitinization, it becomes bell-shaped, the anterior end narrow, with thickened walls, and the posterior end wider, with thinner walls. The capsule is 0.014 mm long and 0.031 mm

wide. Large, elongate glandular cells open inside at the base of the capsule. The two parts of the esophagus are now clearly distinguishable. The intestine is orange and fills almost the entire body cavity. It passes into the rectum, which opens through a long, straight, very thin tube which is surrounded by numerous rectal glands consisting of large cells. The genital primordium may be visible ventrally about halfway along the intestine. According to Moravec, the second-stage larvae are 0.612–0.776 mm long and 0.036–0.054 mm wide; the muscular part of the esophagus is 0.120–0.161 mm long, the glandular part 0.120 mm, and the tail 0.133–0.156 mm long.

The second molt takes place 5–6 days after entry into *Cyclops* according to Kupriyanova, after 8–10 days according to Campana-Rouget, and after 11–12 days according to Moravec.

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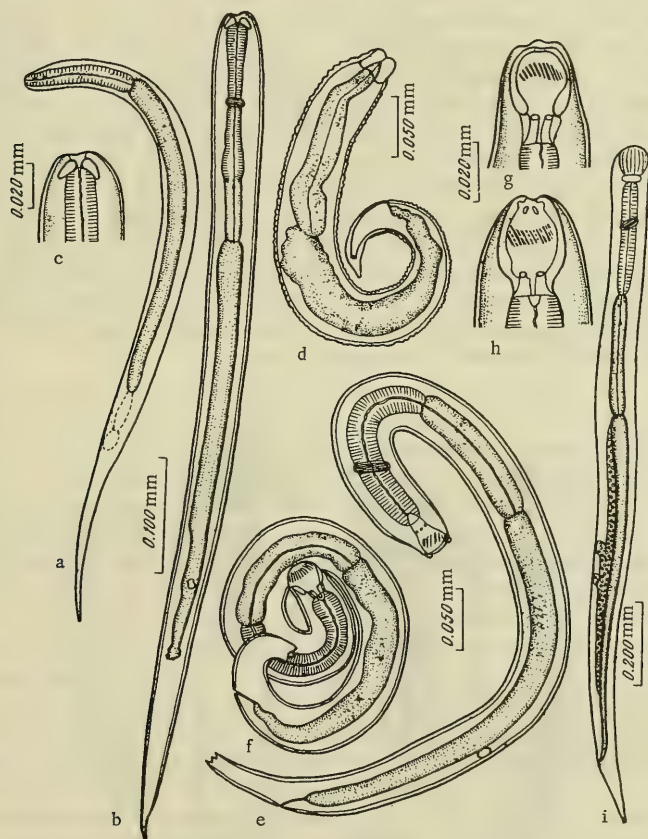


FIGURE 6. *Camallanus lacustris* (Zoega, 1776):

a – first-stage larva, general view, lateral; b – second-stage larva, general view, ventral; c – same larva, cephalic end highly magnified; d – second-stage larva during the molt, lateral; e – third-stage larva from a *Cyclops*, lateral; f – same larva at an older age; g – third-stage larva, cephalic end, lateral; h – same larva, dorsoventral; i – fourth-stage larva from a perch, lateral (after Campana-Rouget, 1961).

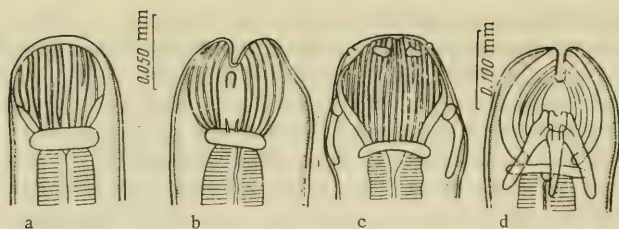


FIGURE 7. *Camallanus lacustris* (Zoega, 1776):

a — fourth-stage larva, cephalic end, lateral; b — same, dorsoventral; c — cephalic end of adult specimen from a perch, lateral; d — same, dorsoventral (after Campana-Rouget, 1961).

The third-stage larva is distinctly differentiated and resembles the adult. A distinct buccal capsule, rounded and not divided into valves, is present, but tridents are still absent. Vertical striae are visible only in the middle (not occupying the entire height of the capsule as in adults); they are very fine, often moniliform, and are irregularly distributed. The esophagus is distinctly divided into a muscular and a glandular part. The caudal end becomes markedly shorter in relation to the length of the body; it is blunt-conical and ends in three distinct pointed processes; the rudiment of a fourth process is often present. The larvae become yellowish. According to Kupriyanova, the third-stage larva is 0.496–0.520 mm long and 0.017 mm wide; Campana-Rouget gives the length as 0.880 mm, width 0.049 mm, length of muscular part of esophagus 0.165 mm, of glandular part 0.125 mm, distance of nerve ring from cephalic end 0.095 mm and distance of anus from end of tail 0.075 mm.

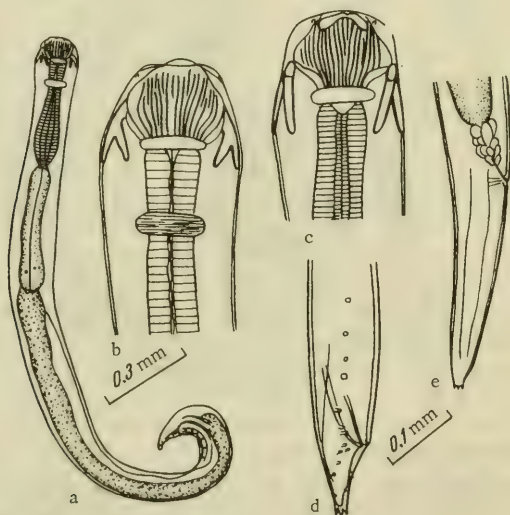


FIGURE 8. *Camallanus lacustris* (Zoega, 1776):

a — general view of male, lateral; b, c — cephalic end, lateral; d — caudal end of male larva before last molt, lateral; e — caudal end of female, lateral (after Moravec, 1969).

Moravec gives the following description of the third-stage larva. Body fairly thick, widest directly behind the buccal capsule. Tail short, thick, ending in three pointed, cone-shaped processes 0.0098 mm long. Cuticle thick, buccal capsule of the *Paracamallanus* type, yellowish-reddish brown, 0.035–0.039 mm long and 0.033–0.036 mm wide, forming two cavities. The first cavity, 0.027 mm deep, consists of two wide lateral valves, with ribs on the inside. The ribs are oblique and reach only to half of the valves, differing in this from the buccal capsule of the fourth-stage larvae and adults. One pair of the four oral papillae is situated dorsolaterally and the other ventrolaterally, at the anterior end of the buccal capsule. Anterior margins of valves strongly pseudochitinized. The second cavity of the buccal capsule resembles that in adult specimens of *Paracamallanus*; it is almost cylindrical and is separated from the anterior cavity of the capsule by a zone consisting of pseudochitinized plates. This second part of the buccal capsule is narrower, depth 0.009 mm and width 0.015 mm. Tridents are still absent. Intestine clearly recognizable. Esophagus consisting of two more or less equal parts, a muscular and a glandular part. The muscular part is usually slightly longer and is lined with cuticle. Three very large glandular nuclei are present at the end of the glandular part. Nerve ring surrounding muscular esophagus 0.109–0.126 mm from the anterior end. Excretory pore situated slightly below the level of the nerve ring 0.117–0.140 mm from the anterior end. Intestine with thick walls, yellow, ending in the colorless rectum, which opens through a straight, thin tube. Anus surrounded by numerous large glandular rectal cells. Length of third-stage larva 0.660–0.829 mm, width 0.054 mm. Length of muscular part of esophagus 0.159–0.217 mm, of glandular part 0.105–0.204 mm. Nerve ring situated 0.109–0.126 mm from the cephalic end. Length of tail 0.051–0.084 mm.

Third-stage larva do not increase in size or develop further in *Cyclops*, although Kupriyanova kept infected *Cyclops* for 32 days. The third-stage larvae are at first very mobile in the host, but their movement slows down after 4–5 days and they coil into a spiral, but do not become encapsulated.

Kupriyanova, Campana-Rouget, and Moravec used *Perca fluviatilis* as definitive hosts to which they fed infected *Cyclops*. Campana-Rouget gives only a description of the fourth-stage larva because of the death of the perch (36 hours after infection). Kupriyanova followed up the development of *C. lacustris* in the definitive host. During the first two weeks of development there is an increase in the body mass without appreciable morphological changes. After 10 days the larvae are 1.092 mm long, 0.043 mm wide, depth of buccal capsule 0.039 mm, its width 0.037 mm; esophagus divided into two parts: anterior part 0.184 mm long, posterior part 0.156 mm long. After 20–25 days tridents begin to develop, and their development is completed 5–7 days later (Kupriyanova, 1954).

Moravec observed the development of *C. lacustris* in perch for 91 days, from the infective stage to the development of larvae in the females. After entering the definitive host, infective larvae attach themselves by the buccal capsule to the intestinal mucosa of the host, mainly the mucosa of the pyloric caeca.

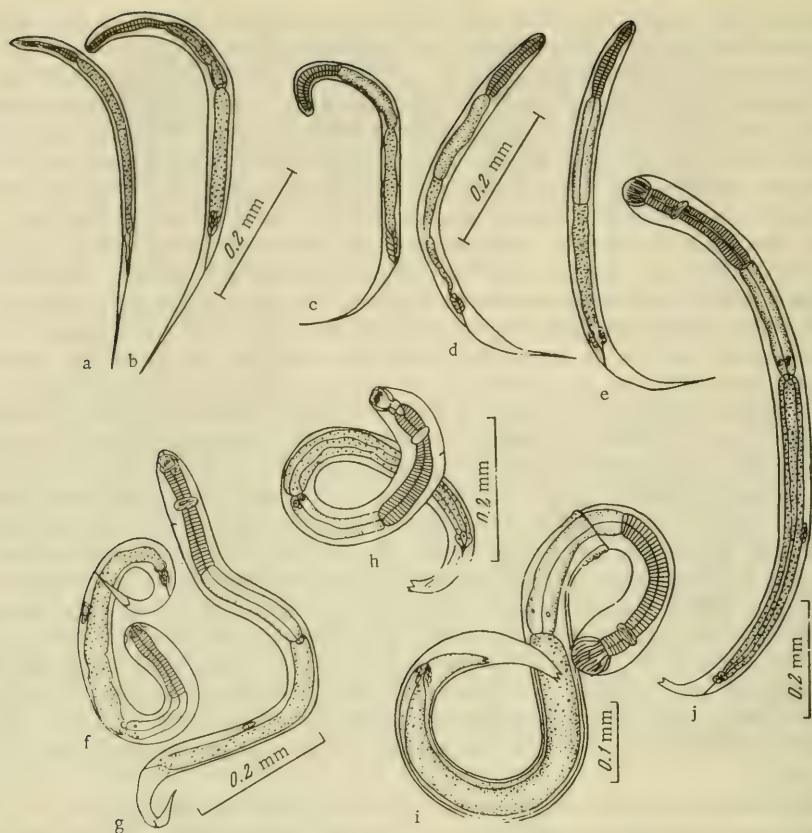


FIGURE 9. Larval development in *Camallanus lacustris* (Zoega, 1776):

a - first-stage larva 17 hours after infection of *Cyclops*, lateral; b - first-stage larva 3 days after infection of *Cyclops*, lateral; c - second-stage larva soon after the first molt; d - second-stage larva 5 days after infection of *Cyclops*; e - second-stage larva after 8 days; f - second-stage larva after 11 days; g - third-stage larva; h - larva during the third molt; i - fourth-stage larva (after Moravec, 1969).

Third-stage larvae taken from the pyloric caeca and from the intestine of perch 4 and 5 days after they had fed on infected *Cyclops* are practically indistinguishable from infective larvae obtained from *Cyclops*. The only difference is that the buccal capsule and the body are slightly wider; 13-15 days later the third larval molt begins, and the buccal capsule changes from the *Paracamallanus* type to the *Camallanus* type.

The fourth-stage larva is 1.7 mm long and 0.078 mm wide. The buccal capsule differs from that of the adult only in the smaller number of striae and in the absence of tridents; the striae become vertical and occupy the entire height of the capsule; a compact ring, like that of the adult, is present. The genital primordium, which was represented by a single cell, becomes longer, as long as the intestine. Buccal capsule 0.095 mm. Length of anterior part of esophagus 0.280 mm, of posterior part 0.300 mm. Nerve ring situated 0.190 mm from cephalic end. Length of tail 0.160 mm.

Moravec noted that the larvae are very similar to the third-stage larvae in the structure of the internal organs. Differences are present only in the structure of the buccal capsule. The larva is about 1 mm long at the molt. After the old buccal capsule has been discarded, the new capsule occupies almost the entire width of the anterior end and is of the Camallanus type. In contrast to the type of capsule of the preceding stage, this capsule has only one cavity; its inner surface has longitudinal ribs, as in the adult.

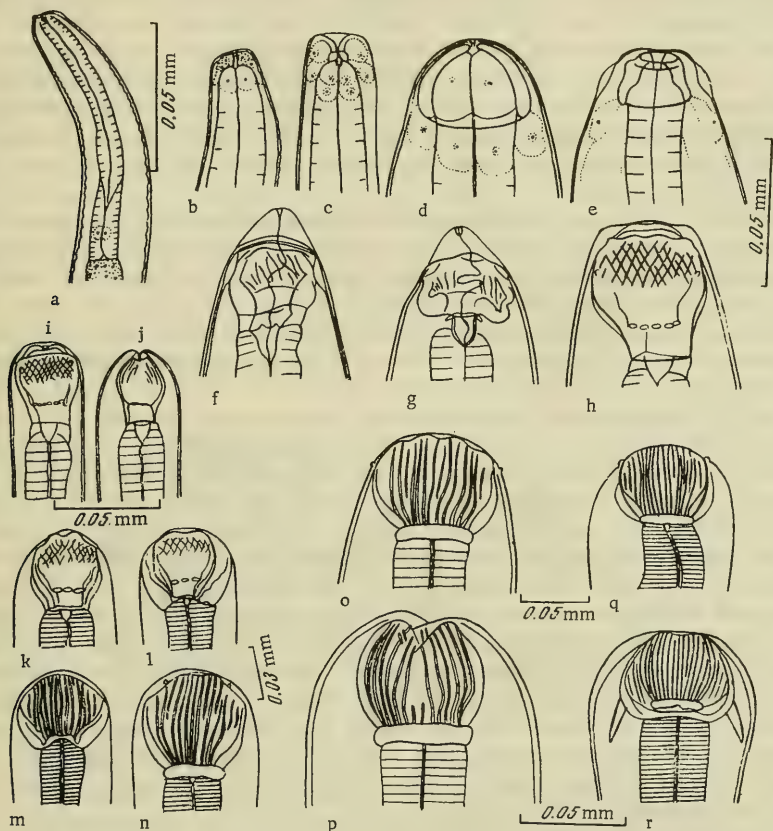


FIGURE 10. Development of the buccal capsule in *Camallanus lacustris* (Zoega, 1776):

a - buccal capsule of first-stage larva; b - g - development of buccal capsule during second stage (before second molt); h - cephalic end of third-stage larva soon after the second molt; i - cephalic end of third-stage larva, lateral; j - same, dorsal; k, l - paracamallanoid buccal capsule of third-stage larva before third molt; m - camallanoid buccal capsule of fourth-stage larva soon after third molt; n - buccal capsule of fourth-stage larva; o - cephalic end of fourth-stage larva, lateral; p - same, dorsal; q, r - buccal capsule of fourth-stage larva before fourth molt (after Moravec, 1969).

Soon after the molt, the buccal capsule of the larva is light-colored, transparent, and the longitudinal ribs (10-12 on each valve) are distinct. The length and width of the capsule are the same, 0.054-0.078 mm. The cuticular ring has not yet developed; only its primordium is present, a weakly pseudochitinized layer, on the proximal end of the esophagus. The cephalic end shows four subterminal papillae, two dorsolateral and two

ventrolateral. The esophagus consists of two parts: a muscular anterior part 0.217–0.340 mm long and a glandular posterior part 0.217–0.353 mm long; the glandular part is slightly longer than the muscular part. Anterior part of esophagus muscular, its inside lined with thick cuticle. The muscular part of the esophagus passes into the glandular part through a valve. The glandular part has more or less the same width its entire length and is united with the intestine by a valve. Three large glandular cells, containing distinct nuclei, are present at the posterior end of the glandular part. Intestine straight, wide, with thick walls, ending in the rectum, which consists of a thin, straight tube and is surrounded by unicellular rectal glands. Tail conical, relatively short, ending in three large conical appendages (like those on the tail of the third-stage larva). Nerve ring surrounding muscular part of esophagus near its anterior end 0.109–0.163 mm from the cephalic end. Excretory pore distinct, situated just below the nerve ring, 0.150–0.225 mm from the cephalic end.

The time of the last molt varies depending on whether the larva is that of a male or a female. The molt of male larvae begins when the larvae are 1.6–1.7 mm long, about 35 days after infection of the definitive host. Female larvae molt when they are more than 2 mm long and markedly later, after 67–69 days. The morphology of juvenile males is identical to that of mature specimens; the only difference is the color of the buccal capsule, which is light and has 16 ribs in the juveniles. The tail is not yet curved ventrally. The lips of the anus protrude above the surface; they appear like small anal papillae in lateral view. Spicules, caudal wings, and tridents of buccal capsule are fully developed. During further development the number of ribs in the buccal capsule increases to 20 and the tail becomes curved ventrally. The lips of the anus are no longer visible. The mature male is 3 mm long.

In the female larvae, the vulva and vagina are already developed during the last molt, but the lips of the vulva do not yet protrude. The tail is long and conical and bears three rudimentary appendages at the end. Copulation begins several days after the last molt. The females continue to grow, but the size of males changes only little. The eggs in the females are oval, with thin walls, $0.136-0.149 \times 0.163$ mm large. The female continues to grow and becomes much longer than the male; the number of eggs in the uterus increases, and cleavage begins; the lips of the vulva protrude above the surface. Three months after infection of the definitive host, viable, mobile larvae are present in the uterus.

Kupriyanova thinks that the development of *C. lacustris* may take place either with one intermediate host or with an intermediate and a reservoir host. In order to determine whether a reservoir host is involved, she made experiments to infect young specimens of *Leuciscus idus*, *L. leuciscus*, and *Abramis brama* with infective larvae and found that the larvae became acclimatized to the intestine of the fish, settling 43 mainly in the anterior part. Development in the young fish did not take place after 37 days. Tridents were absent on the buccal capsule of the larvae; sexual dimorphism was not recognizable.

References: Gnedina and Savina, 1930, pp. 1–20; Ivashkin and Khromova, 1964, pp. 98–104; Kupriyanova, 1954, pp. 373–377; Lyaiman, 1934, p. 135; 1949, p. 306; Parukhin and Kupriyanova, 1953, pp. 497–498; Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 25; Skrjabin, Shikhobalova, Petrov, and Levashov, 1963, pp. 188–190; Sobolev,

1962, pp.270–274; Campana-Rouget, 1961b, pp.25–433; Leiper, 1910a, p.387; Leuckart, 1876, pp.109–112; Linstow, 1909, pp.47–92; Mecznirow, 1866; Mészáros, 1967, p.159; Moravec, 1969, pp.15–33; Wysocka, 1965, p.501.

Camallanus baylisi Karve, 1930 (Figure 11)

Host: *Rana tigrina*.

Localization: intestine.

Distribution: India, Ceylon, Burma.

Description (after Baylis, 1939). Cuticle with delicate striation. Valves of buccal capsule wider than long, wider anteriorly than posteriorly. Each valve with 9–11 longitudinal ribs, usually 11 in mature specimens. A small chitinized toothlike process is situated between two of the ribs. Tridents well developed but of varying size and form. Median branch 0.027–0.04 mm long. Esophagus divided into a muscular and a glandular part. Nerve ring situated about 0.14–0.25 mm, the small cervical papillae 0.19 mm, and excretory pore 0.31–0.37 mm from the cephalic end. Intestine slightly narrower than esophagus.

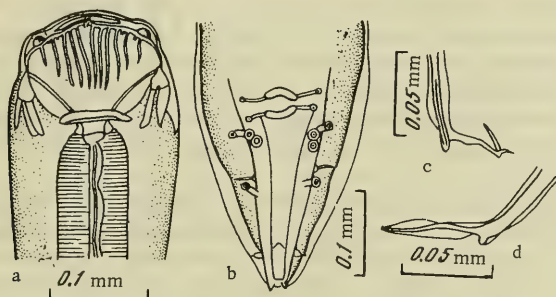


FIGURE 11. *Camallanus baylisi* Karve, 1930:

a – anterior end of female, lateral; b – caudal end of male, ventral; c, d – variants of distal end of right spicule (after Karve, 1930, from Baylis, 1939).

Male. Length 8–9.5 mm, maximum width 0.26–0.27 mm. Dorsoventral width of head near outer corners 0.083–0.098 mm. Length of valves of buccal capsule 0.07–0.09 mm, width 0.1–0.12 mm posteriorly and 0.14–0.19 mm anteriorly. Width of posterior ring of buccal apparatus 0.066–0.070 mm. Length of anterior part of esophagus 0.48–0.52 mm, of posterior part 0.43–0.54 mm.

44 Tail 0.16–0.18 mm long, bifurcate at the end. Length of caudal wings 0.7–0.8 mm, their maximum width about 0.29 mm. Seven pairs of preanal, 2 pairs of adanal, and 6 pairs of postanal papillae. The papillae of the last postanal pair are arranged separately on each side of the body, the papillae of the third pair from the posterior end have a thin end and a thickened base, and the fourth, fifth, and sixth pairs are situated close together. Right spicule

relatively thick, about 0.47 mm long, its distal end with wings and a lateral groove or a denticle. Left spicule thinner, 0.15–0.23 mm long.

Female. Length 14–20 mm, maximum width 0.4 mm. Dorsoventral width of head near outer corners 0.12–0.17 mm. Length of valves of buccal capsule 0.13–0.15 mm, width 0.1–0.12 mm posteriorly and 0.14–0.19 mm anteriorly. Width of posterior end of buccal apparatus about 0.08 mm. Length of anterior part of esophagus 0.60–0.65 mm, of posterior part 0.43–0.54 mm.

Tail about 0.13 mm long, finger-shaped, with three small spines at the end which are larger in immature specimens. Vulva situated before middle of body, 5.35–6.9 mm from the cephalic end. The narrow, muscular vagina passes into the branches of the uterus about 1.5 mm from the vulva. Posterior branch ending about 2.8 mm from the posterior end.

References: Baylis, 1939, pp.210–212; Karve, 1930, p.481; Yamaguti, 1961, p.113.

Camallanus bufonis Agrawal, 1967 (Figure 12)

Host: *Bufo* sp.

Localization: intestine.

Distribution: India.

Description (after Agrawal, 1967). Body slender, of medium size, markedly truncate at both ends. Cuticle thin, with delicate striation. Mouth surrounded by lateral and four submedian papillae. Buccal capsule with two valves, with 10 simple longitudinal ribs of varying length in both sexes. Head slightly curved ventrally. A strongly chitinized ring is present at the connection between the valves and the esophagus. The pair of tridents is sclerotized.

Male. Length 4.99–8.34 mm, width 0.16–0.26 mm. Dorsoventral width of head 0.09–0.14 mm. Valves of buccal capsule wider than long, 0.08–0.10 mm long, 0.10–0.14 mm wide. Tridents well developed except the small median branch, which is 0.030–0.035 mm long; lateral branches 0.055–0.070 mm long. Length of anterior club-shaped muscular part of esophagus 0.43–0.50 mm, width 0.08–0.11 mm. Length of posterior glandular part 0.30–0.45 mm, width 0.08–0.12 mm. Length of esophagus 0.75–0.92 mm. Nerve ring surrounding anterior part of esophagus 0.17–0.22 mm from the anterior end, excretory pore situated 0.19–0.29 mm from anterior end. Length of tail 0.090–0.155 mm.

The caudal wings begin at the cuticular thickening on the ventral surface 45 and extend to the end of the tail. Seven pairs of large pedunculate preanal papillae, 2 pairs of adanal papillae, and 6 pairs of postanal papillae. There are also median papillae at the level of the cloaca. The preanal papillae are almost equally spaced; the adanal papillae are situated laterally, at the level of the cloaca. Three pairs of the postanal papillae are situated close together and three pairs one behind the other. A pair of phasmids is present on the end of the tail. Spicules of different length and form. Right spicule wide, strongly sclerotized, relatively large, 0.36–0.48 mm long, with a spine or process 0.054–0.06 mm long at the end. Left spicule thin, 0.28–0.40 mm long.

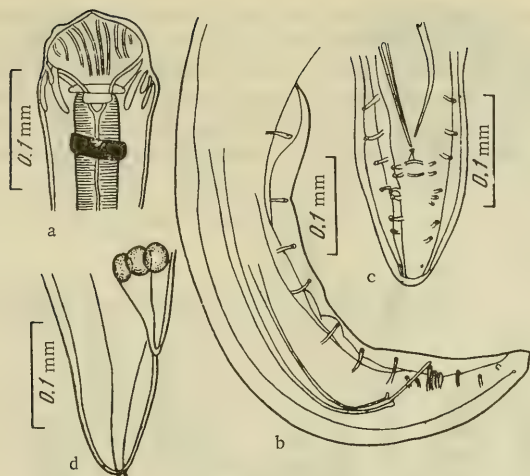


FIGURE 12. *Camallanus bufonis* Agrawal, 1967:

a - anterior end of male, lateral; b - tail of male, lateral; c - same, ventral; d - tail of female, lateral (after Agrawal, 1967).

Female. Length 8.128–12.624 mm, width 0.208–0.240 mm. Dorso-ventral width of head 0.13–0.14 mm. Valves of buccal capsule 0.10–0.13 mm long, 0.11–0.16 mm wide. Tridents well developed, length of median branch 0.030–0.033 mm, of lateral branches 0.055–0.075 mm. Length of anterior club-shaped part of esophagus 0.48–0.67 mm, width 0.06–0.10 mm. Length of glandular part 0.30–0.62 mm, width 0.05–0.12 mm. Length of esophagus 0.78–1.29 mm. Nerve ring situated 0.23–0.26 mm, excretory pore 0.26–0.30 mm from the anterior end. Length of conical tail 0.128–0.176 mm. Vulva situated almost in middle of body, 3.848–6.042 mm from anterior end. Viviparous.

Reference: Agrawal, 1967, pp. 336–338.

Camallanus carangis Olsen, 1954 (Figure 13)

Host: *Caranx* sp.

Localization: intestine.

Distribution: Fiji Islands.

- 46 Description (after Olsen, 1954). Forms with a laterally compressed buccal capsule, with fan-shaped lateral valves, on the inside of which are 25–28 interrupted longitudinal ribs. Two weakly divergent cuticular structures with rounded posterior end extend from the anterior margin of each lateral valve and are directed posteriorly. Cephalic end with 6 papillae, two subventral, two subdorsal, and two lateral. The lateral papillae are smaller and less distinct than the others. A pair of tridents, one dorsal, the other ventral, extend posteriorly from the base of the buccal capsule. The lateral cervical papillae are indistinct.

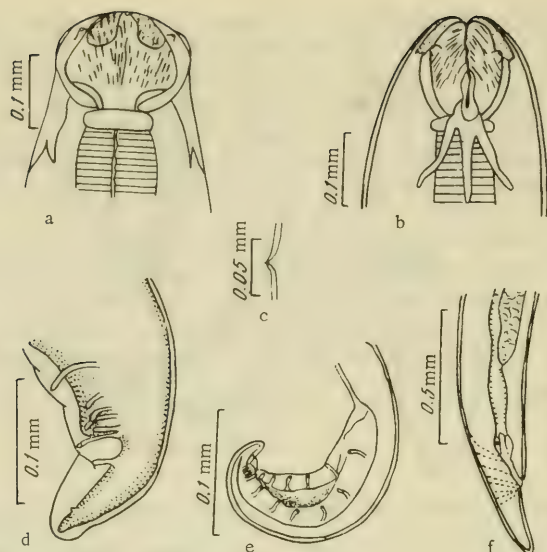


FIGURE 13. *Camallanus carangis* Olsen, 1954:

a - cephalic end of female, lateral; b - same, dorsal; c - cervical papilla of female; d, e - caudal end of male, lateral; f - posterior end of female, lateral (after Olsen, 1954).

Male. Length 16.4 mm, maximum width 0.26 mm. The cuticular structures of the lateral valves form the inner membrane of the buccal capsule; they are 0.120–0.127 mm long. A protruding ring 0.018 mm long and 0.071 mm wide is present at the base of the buccal capsule.

Muscular anterior part of esophagus 1.25 mm long and 0.12 mm wide; glandular posterior part 1.41 mm long and 0.14 mm wide. Nerve ring situated 0.24 mm from the anterior end. Length of tail 0.11 mm. Caudal wings extending anteriorly for 0.81 mm. Fourteen pairs of pedunculate caudal papillae, 7 pairs preanal, 5 pairs adanal, and 2 pairs postanal. The preanal papillae are all of the same size, and the distance between the papillae in each row decreases towards the cloaca. Adanal papillae smaller and not of equal size. The postanal papillae are situated at $1/4$ and $3/4$ of the length of the tail, respectively, from the cloaca; the posterior pair is very small. The testis begins about 1 mm behind the glandular esophagus and extends for 3.34 mm. The vas deferens and ejaculatory duct extend for 9.2 mm; the point of their connection has not been established, but the vas deferens is probably 6.4 mm long and the ejaculatory duct 2.8 mm long. Right spicule 0.22 mm long, left spicule 0.15 mm long.

Female. Length 18.1 mm, maximum width 0.41 mm. The cuticular structures of the lateral valves form the inner membrane of the buccal capsule; they are 0.135–1.53 mm long. A protruding ring 0.022 mm long and 0.093 mm wide is present at the base of the buccal capsule. Median branch of trident 0.097 mm long, lateral branches 0.094 mm long. Cervical papillae situated 0.39 mm from the cephalic end on the left side and 0.42 mm on the right. Muscular anterior part of esophagus 1.40 mm long and 0.18 mm wide. Nerve ring situated 0.29 mm, excretory pore 0.96 mm from cephalic end. Rectum 0.19 mm long, tail 0.26 mm long.

The vulva protrudes markedly above the surface, situated 7.7 mm from the cephalic end. Vagina muscular, thin, maximum width 0.05 mm; it extends posteriorly for 1.22 mm from the vulva, where the anterior and posterior branches of the uterus begin. The parts of the uterus (to 1.5 mm) near the vagina contain developed larvae. The posterior branch of the uterus ends in the ovary, which extends for 1.06 mm from the posterior end of the esophagus.

Reference: Olsen, 1954, pp. 258—260.

Camallanus ceylonensis Fernando and Furtado, 1963
(Figure 14)

Host: *Wallago attu*.
Localization: intestine.
Distribution: Ceylon.

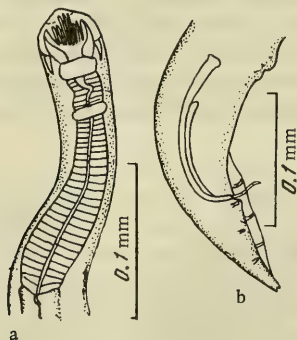


FIGURE 14. *Camallanus ceylonensis* Fernando and Furtado, 1963:

a — anterior end, lateral; b — caudal end of male, lateral (after Fernando and Furtado, 1963b).

Description (after Fernando and Furtado, 1963b). Buccal capsule sclerotized and formed by two lateral valves, each of which bears eight longitudinal ribs. Length of ribs decreasing from the middle to the lateral margins of the valve. Tridents sclerotized, distinct.

Male. Length 4.2 mm, width 0.11 mm. Depth of buccal capsule 0.60 mm, its width almost the same. Muscular part of esophagus 0.30 mm long and 0.09 mm wide, glandular part 0.52 mm long and 0.06 mm wide. Nerve ring situated 0.120 mm from the cephalic end and 0.045 mm from the esophagus. Right spicule 0.120 mm long, left spicule 0.180 mm long. Three pairs of postcloacal papillae, one pair situated immediately behind the cloaca. Length of tail 0.075 mm, end of tail bifurcate.

Female unknown.

Reference: Fernando and Furtado, 1963b, pp. 152—153.

Camallanus cotti Fujita, 1927 (Figure 15)

Hosts: *Huso dauricus*, *Leuciscus waleckii*, *L. chana-konensis*, *Pseudaspius leptcephalus*, *Hemibarbus labeo*, *Gobio gobio*, *Opsariichthys uncirostris*, *Elopichthus bambusa*, *Acanthorhodeus asmusi*, *Parasilurus asotus*, *Rhinogobius similis*, *Chaenogobius macrognatus*, *Cottus pollax*, *Mesocottus haitej*, *Facco platypus*, *Mogurnda obscura*, *Zacco temmincki*.

Localization: small intestine.

Distribution: Amur Basin, Japan (lakes Biwa, Tazawa).

49 Description (after Fujita, 1927). Thin nematodes, cephalic end truncate, posterior end bluntly narrowed in the male and rounded in the female. Cuticle 0.024 mm thick, striated with intervals of 0.006 mm. Buccal capsule formed by two light chocolate-colored chitinous valves, at the base of which is a thickened ring. Length and width of capsule 0.15 mm. Inner surface with 16 thin, almost parallel ribs extending anteroposteriorly. Tridents present, median branch short, about half as long as the lateral branches, which are of equal length, 0.12 mm. Two chitinous trapezoid appendages anteroventrally from each valve. Length of esophagus of female 0.96 mm, anterior part 0.43 mm long. Intestine 3.22 mm long and 0.14 mm wide; anus situated 0.89 mm from posterior end. Nerve ring situated 0.2 mm and excretory pore 0.18 mm from cephalic end.

(48)

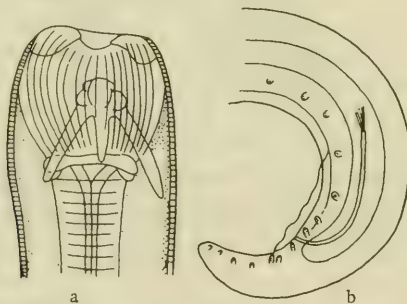


FIGURE 15. *Camallanus cotti* Fujita, 1927:

a - anterior end; b - caudal end of male, lateral (after Fujita, 1927).

Male. Length 3.5 mm, width 0.17 mm. Length of tail 0.16 mm. Two thin, equal spicules 0.02 mm long. Gubernaculum absent. Fourteen pairs of papillae, 7 pairs preanal; first two pairs of preanal and first three pairs of postanal papillae distinctly pedunculate. The last two postanal pairs, which border the end of the tail, small and sessile. Caudal wings weakly developed, 0.27 mm long.

Female. Length 4.72 mm, width 0.35 mm. Vulva situated 3.42 mm from the cephalic end. One ovary, 1 mm long, situated in anterior part of body. Uterus double, its branches of different size. The greater part of the anterior (smaller) branch is situated before the vulva; the posterior (larger)

branch extends anteriorly to the anterior part of the esophagus and posteriorly almost to the end of the body. Vagina extending obliquely posteriorly, 0.35 mm long. Viviparous. Eggs at stage of first cleavage 0.03 mm wide. Length of larva 0.15 mm, width 0.3 mm.

Description (after Yamaguti, 1941, based on four mature males and five mature females).

Male. Length 2.4–2.9 mm, width 0.14–0.16 mm. Length of chitinous buccal capsule 0.080–0.090 mm, including the ring at the base 0.054–0.064 mm wide, with 22 longitudinal ribs. Tridents 0.066–0.075 mm long, median branch 0.054–0.063 mm long, almost as long as the lateral branches. Nerve ring situated 0.12–0.16 mm, cervical papillae 0.28–0.30 mm from the cephalic end. Muscular anterior part of esophagus 0.25–0.28 × 0.072–0.081 mm large, glandular posterior part 0.26–0.34 × 0.075–0.09 mm large. Tail conical, curved ventrally, 0.090–0.120 mm long.

The testis begins in the posterior part of the muscular esophagus or behind it. The first of the 7 pectiniform preanal papillae is situated 0.26–0.33 mm from the cloaca. The first three postanal papillae are pectiniform and are situated close together behind the cloaca; the others are much smaller, and the fourth and fifth are situated close together. The small sixth papilla is situated slightly behind the fifth; it is absent in some specimens. The seventh papilla is situated near the end of the tail. Two riblike adanal papillae are situated just inside the caudal wings. Spicules of different length, ending in a point; right spicule 0.14–0.15 mm long, left spicule 0.1–0.12 mm long.

Female. Length 5.6–6.7, width 0.3–0.4 mm. Buccal capsule 0.108–0.125 mm deep, about 0.15 mm wide, 0.125–0.145 mm long, including the basal ring which is 0.066–0.084 wide. Nerve ring situated 0.2–0.23 mm, cervical papillae 0.43–0.6 mm from the cephalic end. Anterior part of esophagus 0.40–0.46 × 0.11–0.12 mm large, posterior part 0.47–0.51 × 0.098–0.12 mm. Tail 0.8–1.0 mm long, tapering, with blunt end. Ovary beginning 0.045–0.16 mm behind the vulva; it becomes wider and extends straight anteriorly, reaching its maximum width of 0.063–0.12 mm at the distal end; oviduct opening into the uterus 0.27–0.4 mm from anterior end. Vagina 1.0–1.1 mm long, directed posteriorly. The vulva divides the body at the ratio of 1.2–1.45:1. Larvae fixed in boiling water or in alcohol and placed in lactophenol are 0.45–0.48 × 0.021–0.025 mm large.

References: Akhmerov, 1949, p.5; Roitman, 1963b, pp.253–312; Fujita, 1927, pp. 169–171; Yamaguti, 1941, pp.343–396.

Camallanus cynophylectis Sahay, 1966 (Figure 16)

Host: *Rana cynophylectis*.

Localization not given.

Distribution: Bihâr, Patna (India).

Description (after Sahay, 1966a). Body very thin, cuticle thin, delicately striated. Esophagus divided into two parts: a club-shaped muscular anterior part and a cylindrical glandular posterior part; anterior part longer than posterior part. Mouth surrounded by 6 papillae, two lateral

and four submedian. Buccal valves wider than long. Each valve of the buccal capsule bears to 10 longitudinal ribs; between each two of them there is a small chitinized toothlike process. A chitinized ring is present at the connection between valves and esophagus. Tridents well developed. Median branch slightly shorter than the lateral branches, pointed, lateral branches bluntly rounded.

Excretory pore not recognizable.

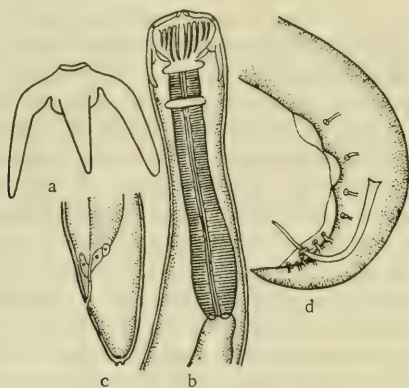


FIGURE 16. *Camallanus cynophylectis* Sahay, 1966:

a - trident; b - anterior end, lateral; c - caudal end of female, lateral;
d - caudal end of male, lateral (after Sahay, 1966a).

Male. Length 7 mm, maximum width 0.168 mm. Length of buccal valves (without posterior ring) 0.084 mm, width 0.126 mm. Width of chitinized ring 0.070 mm. Length of median branch of trident 0.046 mm, of lateral branches 0.06 mm. Nerve ring situated 0.21 mm from cephalic end. Posterior end of body curved ventrally. Tail short, conical, bluntly pointed, 0.16 mm long. Ten pairs of pedunculate papillae, 6 pairs pre-cloacal, one pair on the protruding lips of the cloaca and 3 pairs post-cloacal. Caudal wings present. Only the right spicule found, 0.420 mm long, protruding and chitinized.

- 51 Female. Length 14.826–19.726 mm, maximum width 0.308–0.490 mm. Buccal valves (without posterior ring) 0.126 mm long, 0.178 mm wide. Width of chitinized ring 0.084–0.098 mm. Length of median branch of trident 0.056 mm, of lateral branches 0.070 mm. Nerve ring situated 0.196 mm from cephalic end. Tail 0.140–0.252 mm long, tapering, with small bifid end. Vulva situated before middle of body about 8–9 mm from the anterior end. Vagina muscular, long; two elongate branches of uterus.

Reference: Sahay, 1966a, pp. 53–56.

Camallanus equispiculus Sood, 1968 (Figure 17)

Host: *Heteropneustes fossilis*.
Localization: stomach.

Distribution: India.

Description (after Sood, 1968). Cuticle with fine transverse striation. Body medium-sized, cylindrical, tapering at both ends. Mouth surrounded by 6 papillae, two lateral and four submedian. Buccal capsule sclerotized, formed by two valves, on the inside of which are longitudinal ribs. A strongly developed cuticular ring at the connection between valves and esophagus. A pair of well-developed tridents present. Esophagus consisting of a short muscular anterior part and a long glandular posterior part.

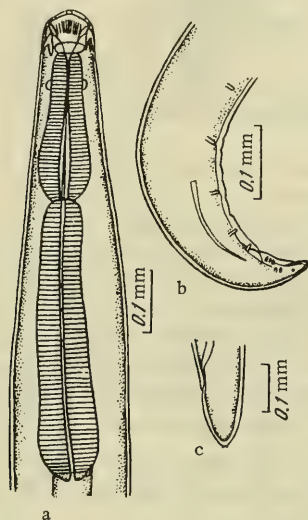


FIGURE 17. *Camallanus equispiculus* Sood, 1968:

a - anterior end of female, lateral; b - caudal end of male, lateral;
c - caudal end of female, lateral (after Sood, 1968).

Male. Length 7.08 mm, width 0.025 mm. Cuticle striated with intervals of 0.003–0.005 mm. Dorsoventral width of head 0.055 mm. Length of buccal valves 0.041 mm, width 0.055 mm; 11 ribs without an armature present. Length of cuticular ring 0.046 mm, width 0.019 mm. Lateral branches of trident 0.022–0.032 mm long, median branch 0.019–0.024 mm long. Muscular anterior part of esophagus 0.21 mm long, 0.097 mm wide, glandular posterior part 0.445 mm long, 0.11 mm wide. Length of esophagus 0.655 mm. Nerve ring situated 0.105 mm, excretory pore 0.12 mm from the cephalic end.

Tail conical, 0.078 mm long. Caudal wings narrow, 0.26 mm long. Eleven pairs of anal papillae, 5 pairs preanal and 6 pairs postanal. The preanal papillae are pedunculate and are equally spaced. The postanal papillae are arranged in three groups. The anterior group consists of 3 pairs of pedunculate papillae, the middle group of 2 pairs, and the last group of one sessile papilla. Spicules equal, slightly sclerotized, widened anteriorly and markedly thinner posteriorly, 0.145 mm long. Gubernaculum absent.

Female. Length 8.34 mm, width 0.045 mm. Cuticle striated with intervals of 0.003–0.006 mm. Dorsoventral width of head 0.06 mm. Buccal valves 0.045 mm long, 0.059 mm wide. Length of cuticular ring 0.049 mm, width 0.017 mm. Lateral branches of trident 0.025–0.036 mm long, median branch 0.021–0.023 mm. Muscular anterior part of esophagus 0.231 mm long, 0.081 mm wide, glandular posterior part 0.439 mm long, 0.097 mm wide. Length of esophagus 0.67 mm. Nerve ring situated 0.103 mm, excretory pore 0.14 mm from the cephalic end. Tail conical, 0.12 mm long, with two processes at the end. Vulva slightly displaced anteriorly from middle of body, situated 3.91 mm from the cephalic end. Viviparous.

Reference: Sood, 1968, pp.91–93.

Camallanus hypophthalmichthys Achmerov, 1954

Host: *Hypophthalmichthys molitrix*.

Localization: intestine.

Distribution: USSR (Amur Basin).

Description (after Dogel' and Akhmerov, 1959).

Male. Length 7.7 mm, width 0.3 mm. Length of larger spicule 0.12 mm. Four or 5 pairs of preanal papillae, 4 pairs of postanal papillae.

Female. Length to 14 mm, width 0.68 mm. Caudal end bearing three conical processes which are characteristic for the genus. Buccal capsule 0.13 mm long and 0.12 mm wide. Esophagus consisting of two parts; anterior part 0.58–0.6 mm long, posterior part 0.78–0.9 mm.

References: Dogel' and Akhmerov, 1959, p.301; Roitman, 1963b, pp.269–271; Skrzjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 26.

Camallanus johni Yeh, 1960 (Figure 18)

Host: *Xenopus* sp.

Localization: intestine.

Distribution: Africa.

Description (after Yeh, 1960a). Small nematodes, widest at the cephalic end, gradually tapering posteriorly, this being more marked in females. Cuticle finely striated. Buccal capsule with two valves and with numerous longitudinal ribs of varying length. The number of ribs is different in males and females. Head slightly curved ventrally. A pair of tridents present. Ventral trident small and indistinctly branched. Dorsal trident large and distinctly trifid. Posterior part of buccal capsule ending in 6 small processes.

53 Male. Length 2.0 mm, maximum dorsoventral width 0.12 mm. Buccal capsule 0.06 mm deep, its dorsoventral width 0.09 mm. Buccal valves with 21 longitudinal ribs. Length of short ventral trident 0.04 mm, of longer dorsal trident 0.05 mm.

Tail 0.06 mm long, with bifid end. Caudal wings present. Seven pairs of large pedunculate precloacal papillae, one pair of small median papillae immediately before the cloaca, one similar pair behind the cloaca, and 6 pairs

of large pedunculate postcloacal papillae. Longer right spicule 0.29 mm long. Left spicule short and wide, 0.04 mm long, resembling a gubernaculum.

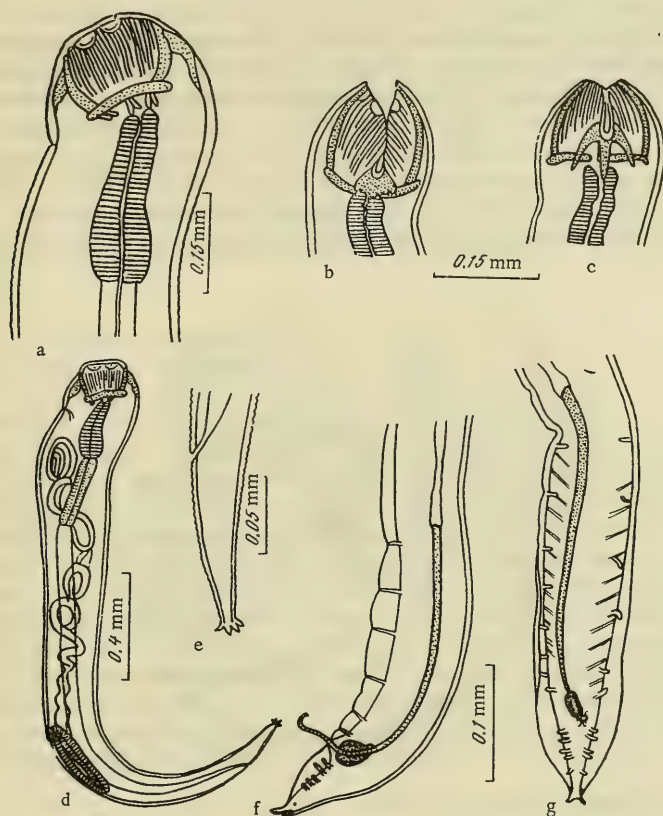


FIGURE 18. *Camallanus johni* Yeh, 1960:

a - cephalic end, lateral; b - same, ventral; c - same, dorsal; d - general view of female, lateral; e - caudal end of female, lateral; f - caudal end of male, lateral; g - same, ventral (after Yeh, 1960a).

54 Female. Length 2.2 mm, maximum dorsoventral width at the excretory pore 0.23 mm. Thirty ribs on each buccal valve. Buccal capsule 0.1 mm deep, its dorsoventral width 0.14 mm. Short ventral trident 0.05 mm long, longer dorsal trident 0.09 mm long. Muscular part of esophagus 0.23 mm long, glandular part 0.29 mm long. Tail 0.11 mm long, ending in a ring of four spines.

Vulva situated near the posterior third of the body, 0.8 mm from the caudal end. The muscular vagina at first extends a short distance posteriorly and then turns anteriorly towards the uterus. Uterus filled with embryos.

Reference: Yeh, 1960a, pp.103-106.

Camallanus inglisi Agrawal, 1967 (Figure 19)

Host: *Rana tigrina*.

Localization: intestine.

Distribution: India.

Description (after Agrawal, 1967). Medium-sized nematodes, markedly truncate at both ends. Cuticle thin, with delicate striation. Mouth surrounded by 6 papillae, two lateral and four submedian. Buccal capsule with two valves with moniliform chitinous ribs (9–11 in females, 10–12 in males). The ribs are of different size in the two sexes. A strongly developed chitinous ring at the connection between valves and esophagus. There is a pair of well-developed tridents. Esophagus consisting of a short muscular anterior part and a long, posteriorly widened glandular posterior part.

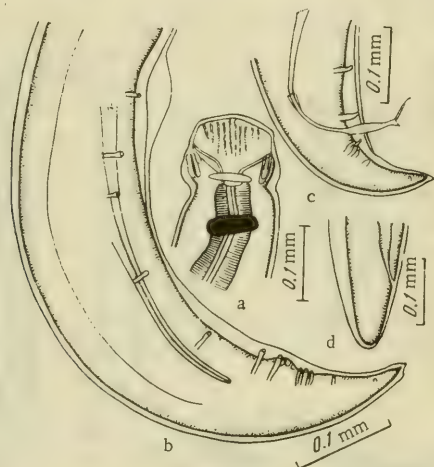


FIGURE 19. *Camallanus inglisi* Agrawal, 1967:

a — anterior end of male, lateral; b, c — caudal end of male, lateral;
d — caudal end of female, lateral (after Agrawal, 1967).

- 55 Male. Length 6.25–8.11 mm, width 0.20–0.28 mm. Dorsoventral width of head at the anterior corners 0.085–0.120 mm. Buccal valves wider than long: length 0.01–0.015 mm, width 0.09–0.092 mm. Tridents well developed. Median branch 0.025–0.028 mm long, lateral branches 0.06 mm long, width 0.009–0.011 mm. Length of club-shaped muscular anterior part of esophagus 0.42–0.46 mm, of glandular posterior part 0.33–0.46 mm, width of this part 0.08–0.11 mm. Length of esophagus 0.75–0.92 mm. Nerve ring surrounding anterior part of esophagus 0.21–0.24 mm from the anterior end. Excretory pore situated behind the nerve ring 0.25–0.30 mm from the anterior end. Tail very short, 0.09–0.12 mm long, its end long, bifid. Caudal wings beginning at the cuticular thickening on the ventral side of the body, 0.41–0.67 from the posterior end, extending to the end of the tail. Seven pairs of pre-anal, 2 pairs of paracloacal, and 5 pairs of postanal papillae. Spicules of different length and form. Right spicule relatively thick, 0.27–0.36 mm long, with a spine or process 0.05 mm long on the distal end. Left spicule 0.37–0.46 mm long.

Female. Length 10.96–18.72 mm, width 0.32–0.48 mm. Dorsoventral width of head 0.14–0.18 mm. Length of buccal valves 0.11–0.12 mm, width 0.16–0.19 mm. Chitinoid ring 0.09–0.11 mm long and 0.01–0.02 mm wide. Length of lateral branches of trident 0.065–0.08 mm, median branch 0.03–0.038 mm. Length of muscular anterior part of esophagus 0.56–0.66 mm, width 0.09–0.15 mm, length of glandular posterior part 0.45–0.59 mm. Nerve ring situated 0.22–0.32 mm, excretory pore 0.28–0.43 mm from the anterior end. Vulva situated before middle of body, 4.96–9.52 mm from anterior end. Viviparous.

Reference: Agrawal, 1967, pp.334–336.

Camallanus kaapstaadi Southwell and Kirschner, 1937
(Figure 20)

Host: frog (*Xenopus laevis*).

Localization: stomach.

Distribution: Africa.

Description (after Southwell and Kirschner, 1937).

Male. Length 2.5–3 mm, width 0.17–0.2 mm. Cuticular striation present. Excretory pore situated in region of nerve ring. Tail 0.09 mm long, ending in two short spines. Caudal wings present. Twelve pairs of caudal papillae: 6 pairs preanal, one pair adanal, and 5 pairs postanal. Mouth surrounded by 6 papillae, 2 lateral and 4 submedian. Buccal capsule consisting of two lateral valves and tridents. Inner surface of each valve with 30–36 longitudinal cuticular ribs. Capsule about 0.1 mm long and 0.12 mm wide, brownish yellow. Its base is supported by a chitinous ring situated at the connection between capsule and esophagus. Esophagus divided into two parts, the anterior part swollen posteriorly, about 0.28 mm long, posterior part glandular, about 0.36 mm long, 0.07 mm wide. Right spicule about 0.33 mm long, left spicule 0.2 mm long.

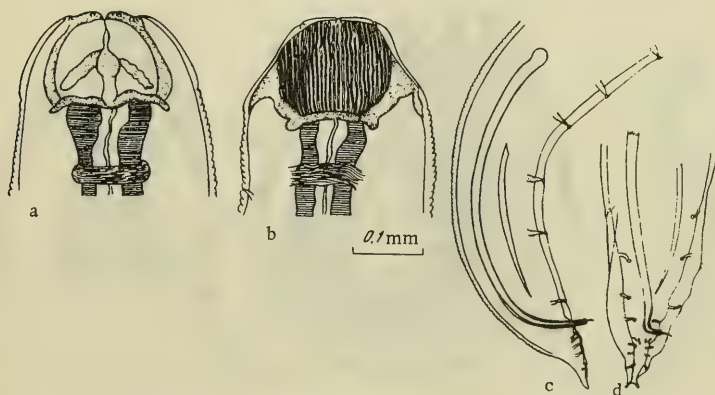


FIGURE 20. *Camallanus kaapstaadi* Southwell and Kirschner, 1937:

a – cephalic end, ventral; b – same, lateral; c – caudal end of male, lateral;
d – same, ventral (after Southwell and Kirschner, 1937).

Female. Length 4.8 mm, width 0.45 mm. Posterior end with three pointed spines. Buccal capsule 0.12 mm long and 0.16 mm wide.

Widened muscular part of esophagus 0.35 mm long, glandular part 0.5 mm long. Vulva situated behind middle of body, $\frac{3}{8}$ of the length of the body from end of tail. The uterus contains mobile larvae, which are 0.29 mm long and have a long, pointed tail.

Reference: Southwell and Kirschner, 1937, pp. 245–265.

Camallanus kirandensis Baylis, 1928 (Figure 21)

Host: *Barbus* sp.

Localization: intestine.

Distribution: Tanganyika.

Description (after Baylis, 1928b).

Male. Length 9 mm, maximum width 0.48 mm. Cuticular striation in middle of body with intervals of about 0.015 mm. Dorsoventral width of head at the anterior corners 0.1–0.13 mm. Length of esophagus 1.82 mm, length of muscular anterior part 0.82 mm. Nerve ring situated slightly before middle of muscular part of esophagus, cervical papillae slightly more anteriorly. Length of chitinous buccal valves, including the posterior ring, 0.11 mm, width 0.1 mm. Each valve bears 22–26 longitudinal ribs and a pair of longitudinal thickenings on the outer surface anteriorly. The thickenings are darker reddish brown than the other part of the plate. Tridents well developed, median branch 0.11–0.14 mm long.

Length of tail 0.16 mm. Ten pairs of caudal papillae, 3 pairs postanal and 7 pairs preanal. Caudal wings weakly developed. Right spicule markedly longer and thicker than the left, 0.22 and 0.18 mm long, respectively.

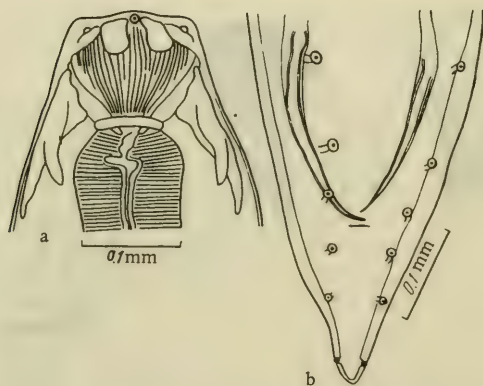


FIGURE 21. *Camallanus kirandensis* Baylis, 1928:

a – cephalic end, lateral; b – caudal end of male, ventral (after Baylis, 1928b).

Female. Length 20 mm, maximum width 0.9 mm. Cuticular striation in middle of body with intervals of about 0.035 mm. Length of esophagus 2.4 mm, of muscular anterior part 1 mm. Length of chitinous valves, including posterior ring, 0.13–0.14 mm. Width of valves 0.12–0.13 mm.

Length of tail about 0.14 mm. Position of vulva not determined. The blind posterior uterine branch extends posteriorly beyond the anus to the posterior end.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 26; Baylis, 1928b, p. 554–556.

Camallanus lissemysus Gupta and Singh, 1959
(Figure 22)

Host: *Lissemys (Punctata) punctata*.

Localization: intestine.

Distribution: India.

Description (after Gupta and Singh, 1959). Cuticle transparent. Cuticular striation weakly marked. Cephalic end rounded and distinctly demarcated from the body. Buccal capsule with two papillae at the anterior end and two cuticular plates 0.01–0.02 mm wide and 0.04 mm long. Buccal valves wider than long. Each valve bears 14–16 longitudinal chitinized ribs and is supported laterally by a continuation of the cuticular ring. The chitinized ribs are arranged in two groups. Some ribs are shorter than the others. The long ribs are closer together distally. Mouth forming a dorso-ventral slit surrounded by the buccal valves. Well-developed tridents are present at the dorsal and ventral corners of the buccal valves. Each trident consists of three branches which extend beyond the beginning of the esophagus. Anterior part of esophagus muscular. Posterior part of esophagus glandular, relatively thinner than the muscular part. Intestine narrower than the esophagus, ending near the posterior end of the body.

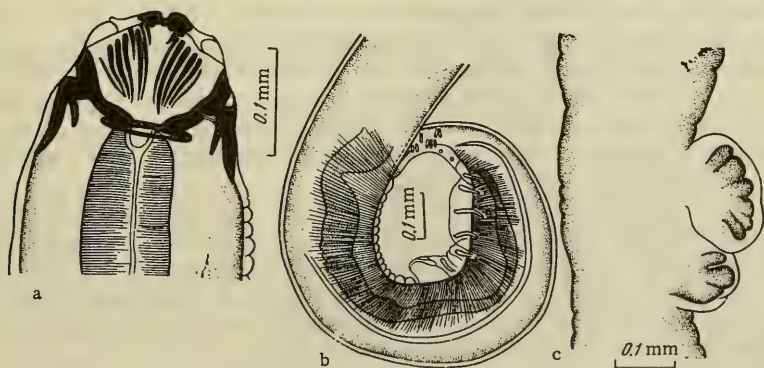


FIGURE 22. *Camallanus lissemysus* Gupta and Singh, 1959:

a – cephalic end, lateral; b – caudal end of male, lateral; c – region of vulva, lateral (after Gupta and Singh, 1959).

Nerve ring situated 0.20–0.22 mm from the anterior end in males and 0.25 mm in females.

Male. Length 4.75–5.0 mm, width 0.21–0.33 mm. Length of buccal valves 0.11–0.13 mm, width 0.13–0.14 mm. Length of branches of trident 0.05–0.1 mm. Length of muscular anterior part of esophagus 0.38–0.44 mm. Tail blunt-conical.

Caudal wings wide, projecting, with constrictions in several places. Six lateral preanal pedunculate papillae which are equally spaced. Three postanal papillae are club-shaped, the middle papilla longer than the others. Two further papillae near the end of the tail support the caudal wings. Another group of three postanal papillae does not extend onto the caudal wings. Two papillae, contiguous to each other, in the posterior part of the tail.

Two adanal papillae. Caudal part distinctly striated. Only the right spicule was found. Length of tail 0.13–0.17 mm. Caudal wings extending almost to the end of the tail.

Female. Length 10.5 mm, width 0.31 mm. Length of buccal valves 0.12 mm, width 0.14 mm. Length of branches of trident 0.05–0.11 mm. Length of muscular anterior part of esophagus 0.49 mm.

Tail blunt-conical. Vulva situated almost in middle of body. Anterior lip of vulva larger than the posterior, length of lips 0.22 and 0.14 mm, respectively. The lips consist of a cuticular swelling with granular content, the swelling divided inside into several lobes. Anterior lip with 6 lobes, posterior lip with only three. Branches of uterus opposite. One ovary. Viviparous.

Reference: Gupta and Singh, 1959, pp.285–289.

59 *Camallanus longitridentatus* Fernando and Furtado, 1963
(Figure 23)

Host: *Clarias batrachus*.

Localization: intestine.

Distribution: Singapore.

Description (after Fernando and Furtado, 1963a). Buccal capsule consisting of two strongly sclerotized lateral valves, each with 9–10 longitudinal ribs without armature; the median ribs extend on the entire length of the valve but become shorter laterally. Buccal capsule passing into the strongly sclerotized pharynx, which opens into the muscular part of the esophagus; then follows the glandular part. There are two pairs of very long tridents, 0.079 mm long.

Male. Length 9.12 mm, width 0.224 mm. Buccal capsule 0.07 mm long and 0.007 mm wide dorsoventrally. Length of pharynx 0.034 mm, maximum width 0.061 mm. Length of muscular part of esophagus 0.432 mm, maximum width 0.115 mm; length of glandular part 0.80 mm, maximum width 0.108 mm. Nerve ring surrounding muscular esophagus 0.094 mm from anterior end of esophagus, 0.194 mm from the cephalic end.

Tail conical, curved ventrally, pointed. Cloaca situated ventrally 0.115 mm from end of tail. Six pairs of precloacal and 6 pairs of postcloacal papillae, one pair situated just before the cloaca and one pair just behind it. Two spicules of different length, 0.09 mm and 0.0756 mm long.

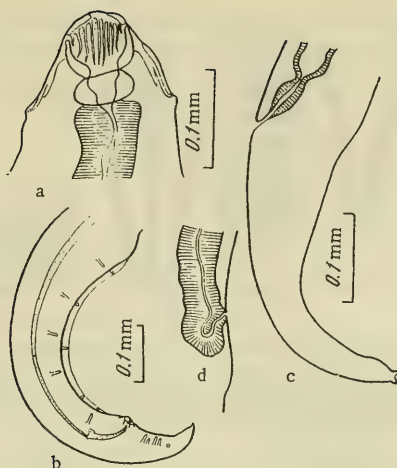


FIGURE 23. *Camallanus longitridentatus* Fernando and Furtado, 1963:

a - cephalic end, lateral; b - caudal end of male, lateral; c - caudal end of female, lateral; d - region of vulva (after Fernando and Furtado, 1963a).

Female. Length 7.2–12.1 mm, width 0.162–0.234 mm. Length of buccal capsule 0.061–0.068 mm, width 0.072 mm. Length of pharynx 0.032–0.036 mm, maximum width 0.025 mm. Muscular part of esophagus 0.320–0.360 mm long, 0.080–0.112 mm wide. Length of glandular part of esophagus 0.900–0.936 mm, maximum width 0.032–0.061 mm. Nerve ring surrounding muscular part of esophagus 0.061–0.115 mm from anterior end of esophagus, 0.162–0.216 mm from the cephalic end. Tail conical, with bifid end. Anus situated 0.216–0.274 mm from end of tail. Vulva situated behind middle of body, dividing the body at the ratio of 1.36:1–1.42. Females contained young larvae.

Reference: Fernando and Furtado, 1963a, pp.61–62.

Camallanus magnorugosus Caballero, 1939 (Figure 24)

Host: *Drymarchon corais melanurus*.

Localization: small intestine.

Distribution: Mexico.

Description (after Caballero, 1939b). Coloration reddish. Cuticle with distinct transverse striation. Anterior end rounded, with 6 pairs of papillae: two median, two ventral, and two dorsal pairs. The mouth consists of a capsule with two lateral valves, on the inner surface of which are 18 chitinized ribs which extend to the beginning of the esophagus. The chitinized plates situated at the base of each valve form the entrance into the esophagus, in the upper part of which there are another two symmetrical chitinized plates. At the connection of the two valves dorsally and ventrally are tridents, the median branch shorter than the lateral branches.

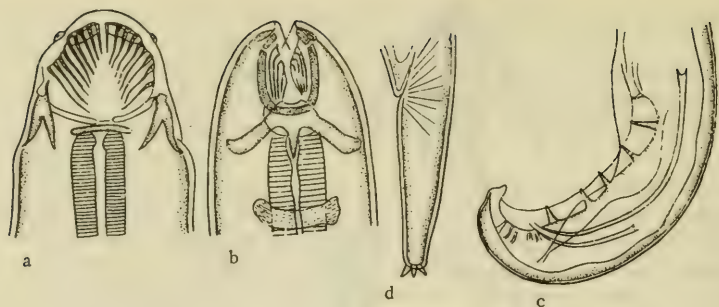


FIGURE 24. *Camallanus magnorugosus* Caballero, 1939:

a - cephalic end of female, lateral; b - same, ventral; c - caudal end of male, lateral;
d - caudal end of female, lateral (after Caballero, 1939b).

Male. Length 6.950–7.585 mm, width 0.253–0.292 mm. Buccal capsule 0.111–0.131 long, 0.139–0.152 mm wide. Lateral branches of trident 0.086 mm long, median branch 0.066–0.070 mm. Basal chitinized plate 0.086–0.092 mm long.

The esophagus consists of two parts: anterior part short, muscular, wider posteriorly, its straight part 0.218–0.234 mm long and 0.074–0.078 mm wide and the wider part 0.189–0.193 mm long and 0.131–0.148 mm wide at the widest place; glandular posterior part of esophagus larger than the muscular part, 0.526–0.585 mm long and 0.131–0.148 mm wide. A small valve is present at the connection of the first and the second part of the esophagus and from the second part to the intestine. Nerve ring situated 0.197 mm, cervical papillae 0.297–0.348 mm from the cephalic end. Excretory pore not found.

Tail with well-developed caudal wings 0.682–1.033 mm long, supported by 6 pairs of lateral pedunculate papillae, 2 pairs of adanal papillae, and 3 pairs of lateral postanal papillae. The first preanal pair of papillae is situated 0.061 mm from the anus, the second pair 0.091–0.098 mm from the anus, the third pair 0.057–0.066 mm from the second, the fourth pair 0.057–0.070 mm from the third, the fifth pair 0.057–0.066 mm from the fourth, and the sixth pair 0.082–0.086 mm from the fifth pair. The first pair of postanal papillae is situated 0.020–0.025 mm, the second pair 0.029 mm, and the third pair 0.049 mm from the anus. Gubernaculum absent. Spicules thin, of different length, larger spicule 0.697–0.717 mm long and 0.016–0.020 mm wide near the manubrium, smaller spicule 0.307–0.320 mm long and 0.008 mm wide. Length of tail 0.131–0.136 mm.

Female. Length 15.100–18.600 mm, width 0.370–0.464 mm. Tail tapering and ending in 3 papillae. Buccal capsule 0.150–0.160 mm long and 0.197–0.230 mm wide, basal plate 0.119–0.131 mm long. Lateral branches of trident 0.123 mm long, median branch 0.098–0.106 mm. Anterior part of esophagus 0.253–0.273 mm long and 0.086–0.097 mm wide in the anterior part and 0.237–0.273 mm long and 0.086–0.097 mm wide in the posterior, wider part. Glandular esophagus 0.585–0.624 mm long and 0.147–0.164 mm wide. Anus situated 0.292–0.370 mm from the posterior end. Nerve ring situated 0.234–0.253 mm, cervical papillae 0.443 mm from cephalic end.

Vulva with protruding lips, situated slightly behind middle of body, 7.400–9.400 mm from the caudal end. Uterus with two branches. Viviparous.

Reference: Caballero, 1939b, pp.76–79.

Camallanus marinus Schmidt and Kuntz, 1969
(Figure 25)

Hosts: *Caranx affinis*, *Gazza minuta*, *Thysanophrys nematophthalmus*, *Trichiurus haumela*.

Localization: small intestine.

Distribution: Philippines.

Description (after Schmidt and Kuntz, 1969). Mouth surrounded by 4 large papillae. Buccal valves wider than long, with equally spaced ribs on the inner surface, some of them not reaching end of valves. Each valve with two lateral thickenings. Teeth absent. Esophagus long, thin; muscular anterior part distinctly separated from the glandular part. Cervical papillae absent. Excretory pore not recognizable. Dorsal and ventral tridents well developed.

Male. Length 12.0–13.0 mm, maximum width 0.230–0.280 mm. Length of buccal valves 0.100–0.104 mm, maximum width 0.117–0.122 mm. Cuticular ring 0.016–0.021 mm long and 0.073–0.075 mm wide. Muscular part of esophagus 1.0–1.1 mm, 0.095–0.113 mm wide, glandular part of esophagus 1.0–1.2 mm long, 0.092–0.120 mm wide. Nerve ring situated 0.085–0.100 mm from cuticular ring. Median branch of trident about 0.083 mm long, lateral branches 0.073 mm.

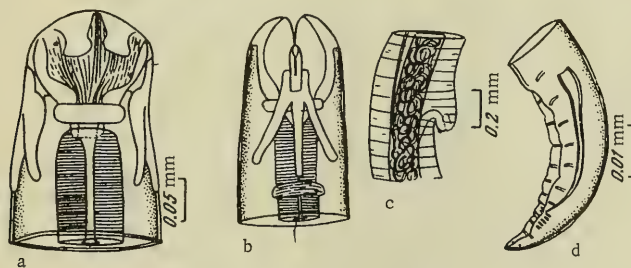


FIGURE 25. *Camallanus marinus* Schmidt and Kuntz, 1969:

a – cephalic end, lateral; b – same, dorsal; c – region of vulva; d – caudal end of male (after Schmidt and Kuntz, 1969).

Tail 0.095–0.105 mm long. Caudal wings well developed, 0.360–0.400 mm long. Seven pairs of preanal pedunculate papillae. Six pairs of pedunculate postanal papillae and a 7th, small, sessile pair situated about 0.026 mm from end of tail. Only one spicule, 0.275–0.285 mm long.

Female. Length 15.0–18.0 mm, width 0.290–0.400 mm length of buccal valves 0.112–0.124 mm, width 0.130–0.150 mm. Cuticular ring 0.018–0.023 mm long and 0.078–0.083 mm wide. Muscular part of esophagus 1.1–1.2 mm, width 0.106–0.130 mm, glandular part of esophagus 1.2–1.25 mm,

maximum width 0.109–0.117 mm. Nerve ring situated 0.085–0.104 mm from cuticular ring. Median branch of trident about 0.090 mm long, lateral branches about 0.083 mm.

Vulva protruding, directed posteriorly, with one raised papilla, situated 8.9–9.0 mm from the cephalic end. Phasmids near end of tail. Length of tail 0.195–0.205 mm. Ovi-viviparous.

Reference: Schmidt and Kuntz, 1969, pp.390–391.

Camallanus mastacembeli Agrawal, 1967 (Figure 26)

Host: *Mastacembelus armatus*.

Localization: intestine.

Distribution: India.

Description (after Agrawal, 1967). Small forms, body tapering at both ends. Cuticle finely striated. Mouth surrounded by 6 papillae, two lateral and four submedian. Buccal capsule sclerotized, formed by two buccal valves, each of which with 9 longitudinal moniliform ribs of varying length. The inner ribs are long; the length of the ribs gradually decreases laterally. The ring at the connection between valves and esophagus is strongly chitinized. A pair of tridents present. The esophagus consists of a short muscular anterior part and a long glandular posterior part.

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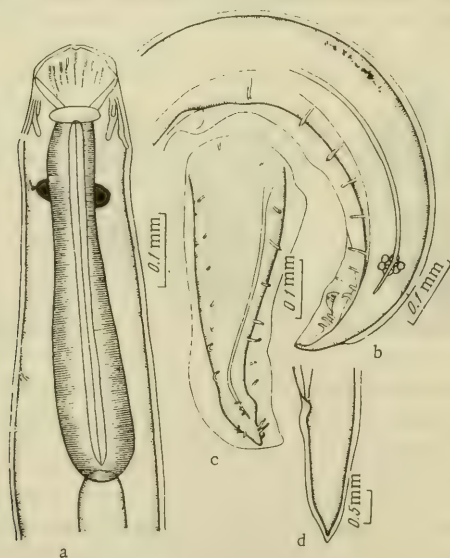


FIGURE 26. *Camallanus mastacembeli* Agrawal, 1967:

a – anterior end of male, lateral; b – caudal end of male, lateral;
c – same, ventral; d – caudal end of female, lateral (after Agrawal, 1967).

Male. Length 8.54–13.16 mm, width 0.19–0.20 mm. Dorsoventral width of head at the anterior corners 0.11–0.12 mm. Valves of buccal capsule 0.085–0.09 mm long and 0.10–0.11 mm wide. Chitinized ring 0.080–0.085 mm long and 0.010–0.020 mm wide. Tridents well developed, median branch 0.03–0.04 mm long, lateral branches 0.07–0.09 mm. Anterior club-shaped muscular part of esophagus 0.48–0.59 mm long and 0.10–0.12 mm wide, glandular posterior part 0.75–0.93 mm long and 0.10–0.11 mm wide. Length of esophagus 0.85–1.49 mm. Nerve ring surrounding anterior part of esophagus 0.22–0.29 mm from cephalic end. Excretory pore situated behind the nerve ring 0.48–0.59 mm from cephalic end.

Caudal wings wide, beginning at the cuticular thickening on the ventral side, reaching to end of tail. Nine preanal papillae, one pair of adanal papillae, and 3 postanal pairs. The preanal papillae are almost equally spaced; the adanal papillae are situated laterally at the level of the cloaca. The postanal papillae are situated close together. Right spicule with widened
64 proximal end, sharply pointed at the distal end, 0.42–0.76 mm long. Left spicule absent.

Female. Length 16.25–24.88 mm, width 0.24–0.30 mm. Cephalic end 0.12 mm wide. Valves of buccal capsule 0.10–0.11 mm long and 0.12–0.13 mm wide. Chitinous ring 0.07–0.09 mm long and 0.02–0.03 mm wide. Lateral branches of trident 0.08–0.10 mm long, median branch 0.030–0.045 mm long. Length of muscular anterior part of esophagus 0.52–0.61 mm, width 0.10–0.12 mm, length of glandular posterior part 0.78–0.93 mm, width 0.10–0.13 mm. Length of esophagus 1.30–1.53 mm. Nerve ring and excretory pore situated 0.50–0.51 mm from cephalic end. Tail 0.16–0.21 mm long, sharply pointed. Vulva situated before middle of body 6.7–9.03 mm from cephalic end. Viviparous.

Description (after Sood, 1968). Forms of medium size and thickness. Mouth surrounded by 6 papillae, two lateral and four submedian. Buccal capsule formed by two valves, with 12 denticulate longitudinal ribs of varying length on the inner surface. A strongly developed cuticular ring at the connection between valves and esophagus. Esophagus consisting of a short muscular anterior part and a long glandular posterior part. A pair of tridents present. Cuticle with fine transverse striation.

Male. Length 9.58 mm, width 0.20 mm. Cuticle striated with intervals of 0.003–0.005 mm. Dorsoventral width of cephalic end 0.11 mm. Length of buccal valves 0.11 mm, width 0.13 mm. Cuticular ring 0.01 mm long and 0.02 mm wide. Tridents well developed, lateral branches 0.07–0.08 mm long, median branch 0.04–0.05 mm long. Length of muscular part of esophagus 0.49 mm, width 0.04–0.05 mm, length of glandular part 0.67 mm, width 0.18 mm. Length of esophagus 1.16 mm. Nerve ring situated 0.202 mm, excretory pore 0.38 mm from cephalic end.

Tail short, with blunt end, 0.09–0.1 mm long. Caudal wings well developed, 0.41–0.62 mm long, reaching to end of tail. Seven pairs of preanal, 2 pairs of adanal, and 3 pairs of postanal papillae. The preanal papillae are widely spaced, the adanal papillae situated at the level of the cloaca, and the three postanal pairs situated close together. A single sensory papilla is situated near the end of the tail. Only the right spicule present, slightly widened anteriorly and markedly tapering posteriorly, 0.40–0.49 mm long. Gubernaculum absent.

Female. Length 19.4 mm, width 0.25 mm. Cuticle striated with intervals of 0.005–0.007 mm. Dorsoventral width of cephalic end 0.13 mm.

Length of buccal valves 0.095 mm, width 0.135 mm. Cuticular ring 0.1 mm long and 0.02 mm wide. Lateral branches of trident 0.055–0.062 mm long, median branch 0.048–0.06 mm. Length of muscular part of esophagus 0.56 mm, width 0.09 mm, length of glandular part 0.73 mm, width 0.12 mm. Length of esophagus 1.29 mm. Nerve ring situated 0.19 mm, excretory pore 0.25 mm from cephalic end. Tail 0.19 mm long, with blunt end. Vulva situated in anterior half of body, 5.63 mm from the cephalic end. Viviparous.

References: Agrawal, 1967, pp.300–334; Sood, 1968, pp.88–91.

65 *Camallanus mazabukae* Kung, 1948 (Figure 27)

Host: bull frog.

Localization: intestine.

Distribution: South Africa.

Description (after Kung, 1948). Small forms. Body tapering slightly posteriorly and curved ventrally, especially in females. Cuticle strongly transversely striated along the whole body. Mouth slitlike, with 6 small papillae, four submedian and two lateral. Lateral valves of buccal capsule with 16–18 longitudinal ribs on each side. There are two tetragonal thickenings at the anterior corners of the valves. Lower part of buccal capsule thicker; its base is markedly thickened and forms a ringed connection with the esophagus. Dorsal and ventral tridents with three almost equal branches which reach beyond the anterior end of the esophagus. Esophagus distinctly divided into two more or less equal parts: a muscular anterior part which is club-shaped in its posterior part and a glandular posterior part which is almost uniformly wide.

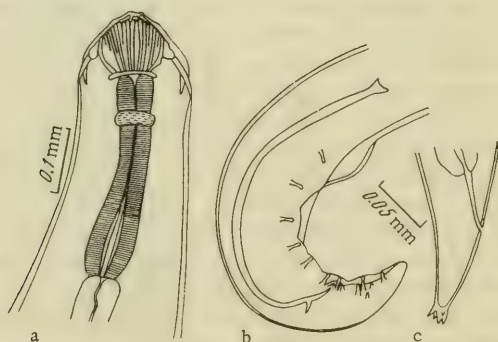


FIGURE 27. *Camallanus mazabukae* Kung, 1948:

a – anterior end, lateral; b – caudal end of male, lateral; c – caudal end of female, lateral (after Kung, 1948).

Male. Length 2.51 mm, width 0.20 mm. Depth of buccal capsule 0.069 mm, its width in the middle 0.075 mm and at the base 0.049 mm. Median branch of trident 0.039 mm long. Nerve ring situated 0.11 mm from cephalic end. Length of esophagus 0.45 mm.

Tail conical, without processes. Caudal wings long and narrow, beginning at the cuticular thickening on the ventral side 0.615 mm from the posterior end and extending to the end of the tail. Ten pairs of lateral pedunculate papillae: 6 preanal, one adanal, and 3 postanal pairs; the first two groups are situated close together, the third group is more isolated. Near the anus are two, possibly three, pairs of small papillae. The ventral surface of the tail bears also one or two pairs of small papillae which are asymmetrically arranged behind the second postanal pair. Only the right spicule is distinct, 0.315 mm long, with a lateral spine at the distal end.

66 Female. Length 3.47 mm, width 0.27 mm. Depth of buccal capsule 0.08 mm, width in the middle 0.095 mm and at the base 0.057 mm. Nerve ring situated 0.14 mm from cephalic end. Length of esophagus 0.63 mm. Tail conical, 0.075 mm long, ending in 5 cuticular spines, three spines longer than the others. Vulva situated slightly behind the middle of the body, recognizable by its ring-shaped thickening. Vagina 0.068 mm long, with muscular walls; it extends posteriorly dorsally and is connected with the two branches of the uterus in the posterior half of the body. Uterus filled with larvae, which are 0.44–0.49 mm long and 0.016 mm wide.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 26; Kung, 1948, p. 141.

***Camallanus multilineatus* Kung, 1948 (Figure 28)**

Host: *Rana catesbiana*.

Localization: stomach.

Distribution: North America.

Description (after Kung, 1948). Coloration white. Cuticular transverse striation present on the whole body. Six papillae (two lateral and four submedian) along the mouth. Valves of buccal capsule strongly chitinated, 67 with 22–24 longitudinal ribs on each side, some of them incomplete. A pair of tetragonal cuticular thickenings on each valve at the anterior corners of the buccal capsule. Capsule wider than long. Tridents extending beyond the anterior end of the esophagus; their branches of almost equal length: 0.105 mm. Cervical papillae very small, situated slightly behind the nerve ring. Excretory pore not detected.

Male. Length 10.5–11.1 mm, width 0.37 mm. Depth of buccal capsule 0.116 mm, width 0.138 mm. Length of esophagus 1.17 mm, its club-shaped anterior part 0.45 mm long. Nerve ring surrounding anterior part of muscular part of esophagus 0.20 mm from cephalic end.

Tail curved markedly ventrally, with caudal wings about 0.75 mm long. Seven pairs of preanal papillae, the first four pairs almost equally spaced, the last three pairs situated close together around the anus. Adanal papillae not visible because the tail is twisted. The first three of the 5 pairs of postanal papillae are situated close together slightly behind the anus, the fourth pair is situated in the middle between anus and end of tail, and the last pair is situated near the end of the tail. Right spicule 0.425 mm long and almost twice as wide as the left, which is 0.4 mm long.

Female. Length 30.4 mm, width 0.74 mm. Depth of buccal capsule 0.15 mm, width 0.76 mm. Length of esophagus 1.46 mm, its club-shaped anterior part 0.628 mm long. Nerve ring surrounding anterior part of

muscular part of esophagus 0.628 mm from cephalic end. Tail 0.15 mm long, rounded, with 3 small cuticular processes at the end. Vulva situated 9.5 mm from cephalic end, without protruding lips. Uterus containing fully formed larvae.

(66)

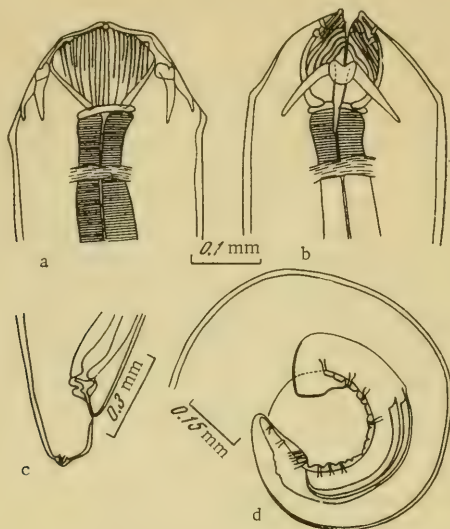


FIGURE 28. *Camallanus multilineatus* Kung, 1948:

a - cephalic end, lateral; b - same, ventral; c - caudal end of female, lateral; d - caudal end of male, lateral (after Kung, 1948).

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 27; Kung, 1948, pp. 145-146.

Camallanus multiruga Walton, 1932 (Figure 29)

Host: frog.

Localization: intestine.

Distribution: West Africa.

Description (after Walton, 1932). Cephalic end with 6 subterminal papillae, three on each valve of the buccal capsule. The valves are supported by a cuticularized ring and have 9-11 cuticularized ribs. There are also markedly shorter intermediate ribs. Tridents present at the corners of the buccal valves. The base of the buccal capsule is surrounded by a small cuticular ring. Esophagus consisting of two parts; nerve ring surrounding anterior end of posterior part. Excretory pore and cervical papillae not recognizable.

Male. Length 9.5 mm, maximum width 0.27 mm. Depth of buccal capsule 0.125 mm, width 0.15 mm. Ring of buccal capsule 0.087 mm wide. Median branch of trident 0.037 mm long. Number of ribs of valves 9-11 long and 9-11 short; teeth in buccal capsule absent. Anterior part of esophagus 0.4 mm long, posterior part 0.45 mm. Nerve ring situated 0.5 mm from cephalic end.

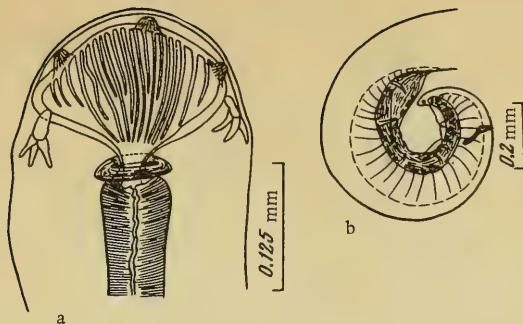


FIGURE 29. *Camallanus multiruga* Walton, 1932:

a — cephalic end of female, lateral; b — caudal end of male, lateral
(after Walton, 1932).

Cloaca situated 0.163 mm from caudal end. Spicules with wings. Right spicule 0.335 mm long, left spicule 0.213 mm. The wings are supported by 16 pairs of pedunculate papillae, seven pairs preanal, two adanal, and seven postanal. There is also a terminal pair of sessile papillae. Tail with single end, bluntly pointed.

Female (immature). Length 8 mm, width in region of vulva 0.23 mm. Depth of buccal capsule 0.125 mm, width 0.175 mm, ring of buccal capsule 0.1 mm wide. Median branch of trident 0.075 mm long; number of ribs of valves 9–11 long and 9–11 short; buccal teeth absent. Anterior part of esophagus 0.43 mm long, posterior part 0.51 mm. Nerve ring situated 0.75 mm from cephalic end. Vulva situated 3 mm from cephalic end. Anus situated 0.137 mm from end of tail, which ends in three distinct spinelike processes.

Reference: Walton, 1932, pp. 151–154.

Camallanus nodulosus Gupta, 1959 (Figure 30)

Host: *Rana cynophylectis*.

Localization: small intestine.

Distribution: East Pakistan.

Description (after Gupta, 1959). Cuticle thin, with delicate striation. Mouth surrounded by two lateral and four submedian papillae. Valves of buccal capsule wider than long. Buccal valves with 9–11 moniliform chitinized ribs (10–11 in females, 9–11 in males).

Tridents well developed, median branch small.

Male. Length 7.9–11.1 mm, width 0.22–0.3 mm. Length of buccal valves 0.08–0.09 mm, width 0.09–0.11 mm. The wide, thick chitinized ring at the connection between valves and esophagus is 0.06–0.085 mm wide. Median branch of trident 0.03–0.04 mm long, lateral branches 0.04–0.06 mm. Club-shaped anterior part of esophagus 0.09–0.1 mm long, cylindrical glandular posterior part 0.34–0.40 mm long, 0.09–0.11 mm wide. Nerve ring situated 0.15–0.18 mm from cephalic end.

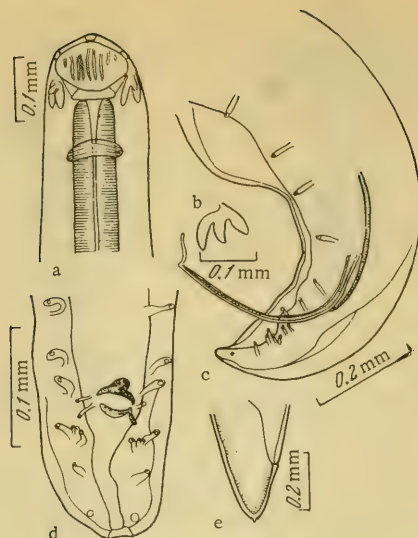


FIGURE 30. *Camallianus nodulosus* Gupta, 1959:

a - cephalic end, lateral; b - trident; c - caudal end of male, lateral;
d - same, ventral; e - caudal end of female, lateral (after Gupta, 1959).

Tail 0.12–0.13 mm long, bifid. Caudal wings long, narrow, beginning from the cuticular swelling on the ventral side, 0.63 mm from the posterior end, and extending to end of tail. The 7 pairs of precloacal papillae are more or less equally spaced, except the two posterior pairs, which are situated close together near the cloaca. Two pairs of small pedunculate paracloacal papillae. Six pairs of postcloacal papillae, the two posterior pairs separated from the others, the fifth pair pedunculate, and the sixth sessile. The first four pairs of postcloacal papillae are situated close together, forming a group on each side. Right spicule relatively thicker, 0.44–0.45 mm long, with a tooth or process about 0.05 mm from the distal end; left spicule thinner, 0.27–0.36 mm long.

Female. Length 21.6–23.35 mm, width 0.4–0.5 mm. Length of buccal valves 0.11–0.13 mm, width 0.13–0.18 mm. Chitinized ring at connection between valves and esophagus 0.09 mm wide. Median branch of trident 0.027–0.042 mm long, lateral branches 0.07–0.09 mm. Club-shaped anterior part of esophagus 0.64–0.69 mm long, 0.11–0.18 mm wide. Cylindrical glandular posterior part of esophagus 0.46–0.56 mm long, 0.1–0.11 mm wide. Nerve ring situated 0.175 mm, excretory pore 0.42 mm from cephalic end.

70 Tail 0.10–0.19 mm long, with rounded end, with two small cuticular processes at the end. Vulva situated before middle of body, 9.6–10.05 mm from anterior end, a distinct lobelike structure forming the anterior lip.

Reference: Gupta, 1959, pp. 771–773.

Camallanus ophiocephali Pearse, 1933 (Figure 31)

Hosts: *Ophiocephalus striatus*, *O. marulis*.

Localization: intestine.

Distribution: Thailand, India.

Description (after Pearse, 1933). Cuticular transversely striated. Chitinized buccal valves with 18–26 ribs, the chitinized pharynx behind them hemispherical and half their size.

Male. Length 4.7 mm, width 0.5 mm. Tridents directed toward posterior margin of valves. Four pairs of postanal papillae and a pair of discoid processes at the end of the tail. Two pairs of papillae situated before the anus and 6 pairs some distance before them. Right spicule 0.35 mm long, left spicule 0.13 mm. Transverse crests pass on the ventral posterior part.

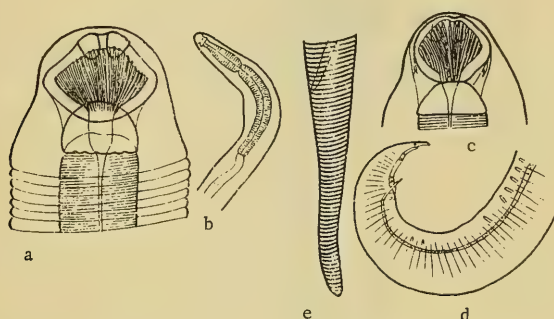


FIGURE 31. *Camallanus ophiocephali* Pearse, 1933:

a, b, c — anterior end, different aspects; d — caudal end of male, lateral; e — caudal end of female, transverse striation shown (after Pearse, 1933).

Female. Length 11.9 mm, width 0.8 mm. Depth of chitinized buccal capsule 0.06 mm. Length of muscular part of esophagus 0.3 mm, of glandular part 0.7 mm. Tail straight, tapering, with bluntly rounded end, 0.28 mm long. Vulva situated slightly before middle of body.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 27; Pearse, 1933, pp. 183–184.

71 *Camallanus oxycephalus* Ward and Magath, 1916
(Figure 32)

Host: *Ambloplites rupestris*.

Localization: intestine.

Distribution: North America.

Description (after Tornquist, 1931). Medium-sized forms. Cuticle thin, with delicate striation. Mouth rounded, with 6 papillae, four submedian and two lateral. Buccal apparatus consisting of two reddish brown chitinoid valves separated by a wide longitudinal groove. Inner surface of valves with

10–12 (12 in females and 10–12 in males) complete and incomplete longitudinal ribs. The ribs are markedly wider anteriorly in females.

Tridents yellowish brown, straight, chitinous, with rounded or blunt posterior ends. They are attached directly to the corners of the valves, dorsal and ventral chitinous bodies absent. Esophagus divided into a club-shaped muscular anterior part and a cylindrical glandular posterior part. The posterior part opens into the intestine through three small nuclear valves. Intestine wider than posterior part of esophagus and with wide lumen. The cells of the intestinal wall are distinct and contain granular protoplasm with small nuclei. Rectum small, opening into the anus in the female and into the cloaca in the male. Rectum 0.1 mm long in the female, very narrow. Three nuclear rectal glandular cells at the connection between intestine and rectum.

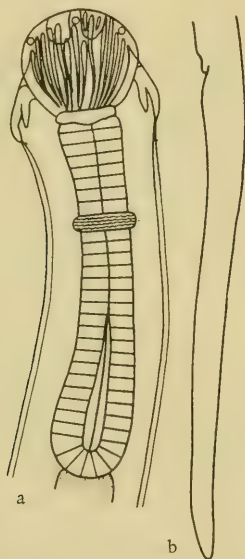


FIGURE 32. *Camallanus oxycephalus* Ward and Magath, 1916;

a - anterior end, lateral; b - posterior end of female, lateral (after Tornquist, 1931).

Male. Length 8.5–8.8 mm, width 0.25–0.29 mm. Dorsoventral width of head 0.07–0.085 mm. Length of buccal valves 0.062–0.066 mm, maximum width 0.070–0.075 mm. Length of tridents 0.055–0.058 mm. Posterior ring of buccal capsule 0.028 mm wide. Length of esophagus 0.725–0.760 mm. Cuticle striated with intervals of 0.002–0.0035 mm. Nerve ring surrounding anterior part of esophagus 0.13–0.15 mm, the small cervical papillae situated 0.24 mm, and the excretory pore 0.3 mm from the cephalic end.

Caudal wings well developed. The conical, pointed tail is short, 0.048–0.05 mm long and is curved ventrally. Caudal papillae large, pedunculate. Five pairs of precloacal and numerous pairs of postcloacal papillae. The first three pairs of precloacal papillae are lateral. The two posterior pairs of precloacal papillae and all postcloacal papillae are ventral. All papillae

72 of the same size. Right spicule thick, with wings on a large part, 0.19–0.21 mm long. Its end is hooked. Left spicule weakly chitinized, threadlike, without wings, 0.09–0.10 mm long. Gubernaculum L-shaped, 0.028 mm long.

Female. Length 23–25 mm, width 0.42–0.46 mm. Dorsoventral width of head at the anterior corners of buccal capsule 0.09–0.10 mm. Length of buccal valves 0.09 mm, maximum width 0.11–0.125 mm. Length of tridents 0.075 mm. Posterior ring of buccal capsule 0.045 mm wide. Length of esophagus 10.6–11.6 mm. Nerve ring surrounding anterior part of esophagus 0.16–0.17 mm, the small cervical papillae situated 0.4 mm, and excretory pore 0.42 mm from the cephalic end. Cuticle striated with intervals of 0.003–0.005 mm.

Tail 0.46–0.50 mm long, tapering, with a small widening before the end. Lips of vulva forming a tubular process, 0.33 mm long, which is dorsoventrally flattened and directed posteriorly. In specimens 25 mm long the process begins 11 mm from the anterior end. Vulva situated on the ventral surface of the process, at its end. The narrow vagina passes from the vulva to the base of the process and then extends posteriorly for 1.4 mm, where it passes into the two opposite branches of the uterus. There is a single anterior ovary, situated near the anterior end of the intestine. Posterior branch of uterus without an ovary. Viviparous. Uterus filled with small larvae with pointed tail. Length of larvae 0.10–0.12 mm.

Reference: Tornquist, 1931, pp. 110–114.

Camallanus pipientis Walton, 1935 (Figure 33)

Host: *Rana pipiens*.

Localization: intestine.

Distribution: USA.

Description (after Walton, 1935).

Male. Length 7.5–8.0 mm, maximum width 0.225 mm. Size of buccal capsule 0.11×0.13 mm. Twelve to 15 ribs on the valves, teeth absent in buccal capsule. Length of anterior part of esophagus 0.435 mm, of posterior part 0.88 mm. Nerve ring situated 0.2 mm, excretory pore 0.625 mm from cephalic end.

73 Cloaca situated 0.723 mm from end of tail. Right spicule 0.55 mm long, with a hooklike process at the end which is 0.055 mm long, left spicule 0.3 mm long. Caudal papillae pedunculate: 2 pairs paraclonal, 4 pairs postclonal, and one pair subterminal.

Female. Length 10.25 mm, width at level of vulva 0.44 mm. Size of buccal capsule 0.11×0.145 mm. Twelve to 15 ribs on the valves; teeth absent in buccal capsule. Length of anterior part of esophagus 0.457 mm, of posterior part 0.8 mm. Nerve ring situated 0.15 mm, excretory pore 0.65 mm from cephalic end. Anus situated 0.183 mm from end of tail which bears three processes. Vulva situated 5.5 mm from cephalic end. Viviparous.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 28; Walton, 1935, p. 33.

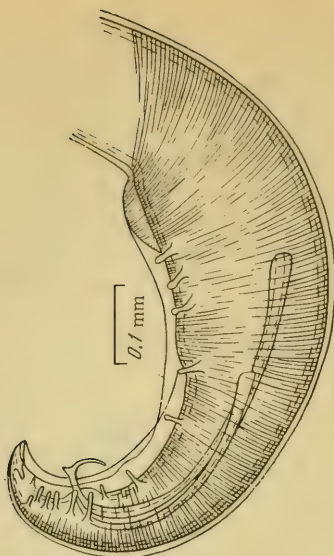


FIGURE 33. *Camallanus pipientis* Walton, 1935.

Caudal end of male, lateral (after Walton, 1935).

Camallanus ranae Khera, 1954 (Figure 34)

Host: *Rana cynophylectis*.

Localization: intestine.

Distribution: India.

Description (after Khera, 1954). Medium-sized forms. Cuticle thin, with delicate transverse striation. Mouth surrounded by 6 papillae, two lateral and four submedian. Valves of buccal capsule wider than long and wider anteriorly than posteriorly. Buccal valves strongly chitinized, with 9–11 ribs on each (11 in females, 9–11 in males). A small chitinized toothlike process is sometimes situated between two longitudinal ribs. The chitinized ring and the small cavities behind it are demarcated by chitinized material and
74 separate the buccal capsule from the esophagus. Tridents well developed, median branch small and difficult to see. Esophagus divided into a club-shaped muscular anterior part and cylindrical glandular posterior part. Anterior part longer.

Three projecting valves between posterior part of the esophagus and the intestine. Intestine as wide as posterior part of esophagus, with wide lumen. Cells of intestinal wall not recognizable. Rectum short, narrow.

Nerve ring surrounding the anterior part of the esophagus.

Male. Length 6.75–7.00 mm, width 0.156–0.188 mm. Dorsoventral width of cephalic end at its anterior corners 0.063 mm. Valves of buccal capsule 0.094 mm long, maximum width 0.11–0.12 mm. Chitinized ring 0.078–0.086 mm wide. Median branch of trident 0.012 mm long, lateral branches 0.05–0.06 mm. Length of anterior part of esophagus 0.438–0.470 mm, of posterior part 0.330–0.376 mm. Nerve ring situated 0.2 mm, cervical papillae 0.25 mm from cephalic end.

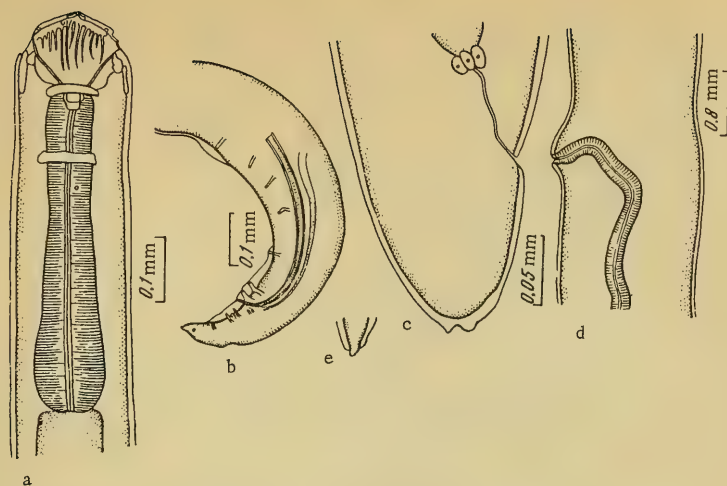


FIGURE 34. *Camallanus ranae* Khera, 1954:

a - anterior end of male, lateral; b - posterior end of male, lateral; c - caudal end of female, lateral; d - region of vulva, lateral; e - end of tail of male, lateral (after Khera, 1954).

Tail 0.13 mm long, with bifid end. Caudal wings wide, 0.52–0.58 mm long and 0.12 mm wide, ending just before the end of the tail. Seven pairs of precloacal, 2 pairs of cloacal, and 5 pairs of postcloacal papillae. The papillae of the posterior (fifth) pair are sessile and separated; those of the fourth pair are also separated but pedunculate. The first three pedunculate pairs of postcloacal papillae are situated close together. The two cloacal pairs of papillae are small and pedunculate. The last two pairs of precloacal papillae are situated close together and to the cloaca; the other precloacal papillae have conical endings and are equally spaced. All caudal papillae except the two cloacal pairs are ventrolateral. Two pairs of cloacal papillae are lateral. Right spicule longer than the left, thick, 0.445 mm long, with wings extending its entire length. Its distal end is simple, without a lateral spine or tooth. Left spicule weakly chitinized, thinner than the right, markedly more slender in its posterior half, 0.310–0.355 mm long.

Female. Length 23.0–24.9 mm, width 0.53–0.58 mm. Dorsoventral width of cephalic end at the anterior corners 0.108–0.125 mm. Valves of buccal capsule 0.125 mm long, maximum width 0.168–0.180 mm. Chitinized ring 0.11–0.14 mm wide. Median branch of tridents 0.020–0.022 mm long, lateral branches 0.055–0.065 mm. Length of anterior part of esophagus 0.680–0.736 mm, of posterior part 0.57–0.61 mm. Nerve ring situated 0.23–0.25 mm, the small cervical papillae 0.28 mm from cephalic end.

Tail 0.17–0.20 mm long, with slightly bifid end. Vulva situated before middle of body, 9.84 mm from the cephalic end in a specimen 24.9 mm long. Vulva slitlike-oval, situated in middle of ventral side. Vagina muscular, 1.3–1.4 mm long, directed posteriorly. Two opposite uteri. The spiral of the posterior branch extends posteriorly for 0.28–0.32 mm. Posterior branch ending blind, ovary absent. Anterior branch of uterus with a single anterior ovary which is situated 0.25–0.50 mm behind the

- 75 anterior end of the intestine. Larvae 0.09–0.12 mm long, with blunt cephalic end and pointed caudal end.

Reference: Khera, 1954, pp.96–100.

Camallanus salmonae Chakravarty, 1942

Host: trout (*Salmo* sp.).

Localization: intestine.

Distribution: India.

Description (after Chakravarty, 1942).

Male not known.

Female (one specimen). Length 12 mm, width 0.38 mm. Cuticle transversely striated. Two pairs of cephalic papillae. Buccal valves with 15 longitudinal, weakly marked ribs. Tridents absent. Length of buccal capsule 0.14 mm, width 0.15 mm. Length of muscular part of esophagus 0.39 mm. Nerve ring situated 0.21 mm from cephalic end.

Tail finger-shaped, with slightly rounded end without spines. Caudal papillae not found. Vulva situated almost in middle of body, with a small cuticular widening in its region.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.28; Chakravarty, 1942, pp.441–442.

Camallanus singhi (Ali, 1956) Yeh, 1960 (Figures 35, 36)

Synonym: *Neocamallanus singhi* Ali, 1956

Host: *Ophiocephalus punctatus*.

Localization: intestine.

Distribution: India.

Description (after Ali, 1956). Small forms, with cylindrical body and bluntly rounded cephalic end. Caudal end blunt in females, conical in males. Cuticle thin, not striated. Nerve ring surrounding esophagus at about a third of its length from the cephalic end. Cephalic end with two pairs of submedian papillae and a pair of lateral amphids. Cervical papillae not found. Buccal capsule consisting of two valves which are slightly wider than long. Two triangular chitinous processes at the anterior margin of the buccal capsule. Esophagus consisting of two parts, its length about $1/5$ of the length of the body. Intestine markedly narrower than esophagus.

Male. Length 3.96–4.66 mm, maximum width 0.13–0.15 mm. Dorso-ventral width of cephalic end 0.065 mm. Excretory pore situated 0.16–0.18 mm from anterior end. Buccal capsule without basal ring 0.051 mm long, width 0.061 mm.

Muscular anterior part of esophagus 0.26–0.30 mm long, glandular posterior part 0.52–0.56 mm long. Length of esophagus 0.78–0.86 mm.

- 76 Testis threadlike, extending to the glandular part of the esophagus. Caudal end with lateral cuticular wings which extend for 0.39 mm and become narrower toward the conical tail. Spicules weakly chitinized, right spicule 0.178 mm long, left spicule 0.088 mm. Nine pairs of riblike caudal

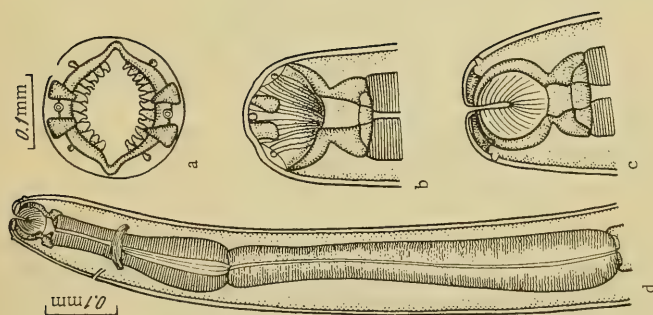


FIGURE 35. *Camallanus singhi* (Ali, 1956) Yeh, 1960:
a - cephalic end, apical; b - same, dorsoventral; c - same, lateral; d - anterior end of male, lateral (after Ali, 1956).

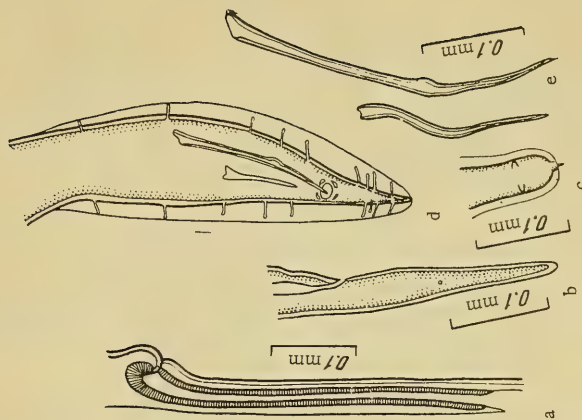


FIGURE 36. *Camallanus singhi* (Ali, 1956) Yeh, 1960:
a - region of vulva; b, c - caudal end of female; d - caudal end of male, ventral; e - spicules (after Ali, 1956).

papillae extend into the caudal wings. There are also two pairs of circum-anal papillae near the cloaca. Five pairs of other papillae are preanal and 4 pairs postanal. The distance between the first and second preanal pairs and between the second and third pairs is about twice the distance separating the third, fourth, and fifth pairs. The first three pairs of postanal papillae are displaced, and the last pair is situated slightly separately, in the middle between the third pair and the end of the tail which is 0.10–0.14 mm long.

Female. Length 6.35–6.48 mm, maximum width 0.14–0.19 mm. Dorsoventral width of cephalic end 0.073 mm. Excretory pore situated 0.20–0.24 mm from anterior end. Buccal capsule (without basal ring) 0.073 mm long, 0.076 mm wide. The single ovary extends into the anterior third of the body and then turns posteriorly and reaches almost to the vulva. Posterior branch of uterus blind, situated in the anal region. Both branches of uterus 77 opening together into the muscular ovejector which is 0.43 mm long. Vulva with two distinct lips. Anterior lip larger and slightly overlapping the posterior lip. Vulva situated 2.9–3.34 mm from cephalic end. Uterus containing embryos 0.19 mm long and 0.011 mm wide. Tail 0.18–0.26 mm long, with a pair of phasmids 0.026 mm from the end. End of tail with 3 papillae, two lateral and one terminal.

References: Ali, 1956, pp.19–21; Yeh, 1960a, pp.103–106.

Camallanus thapari Gupta, 1959 (Figure 37)

Host: *Rana tigrina*.

Localization: small intestine.

Distribution: Pakistan.

Description (after Gupta, 1959).

Male. Length 9.27–13.1 mm, width 0.25–0.29 mm. Cuticle thin, with delicate striation. Mouth surrounded by 2 lateral and 4 submedian papillae. Dorsoventral width of cephalic end 0.1–0.13 mm. Buccal capsule formed by two valves 0.076–0.09 mm long (without posterior ring) and 0.10–0.11 mm wide. Valves with 9–11 crests. A large chitinized ring 0.075–0.080 mm wide at the connection between valves and esophagus. Tridents well developed; median branch 0.040–0.048 mm long, lateral branches 0.050–0.060 mm. 78 Club-shaped muscular anterior part of esophagus 0.46–0.50 mm long and 0.09–0.1 mm wide, cylindrical glandular posterior part 0.40–0.44 mm long and 0.09–0.10 mm wide.

Nerve ring situated 0.14–0.17 mm, excretory pore 0.36 mm from cephalic end.

Tail 0.14–0.15 mm long, with bifid tip. Caudal wings long, narrow, beginning from the cuticular swelling on the ventral side, maximum width about 0.03 mm. Six pairs of preanal, 2 pairs of small, pedunculate adanal, and 5 pairs of postanal papillae. The two posterior pairs of the postanal papillae are pedunculate and isolated; the three anterior pairs are pedunculate and situated close together. The three posterior pairs of precloacal papillae are situated close together; the other precloacal papillae are isolated. Right spicule relatively thick, about 0.40–0.46 mm long, with a lateral process or tooth 0.04 mm from the end. Left spicule thinner, slightly widened anteriorly, 0.28–0.32 mm long.

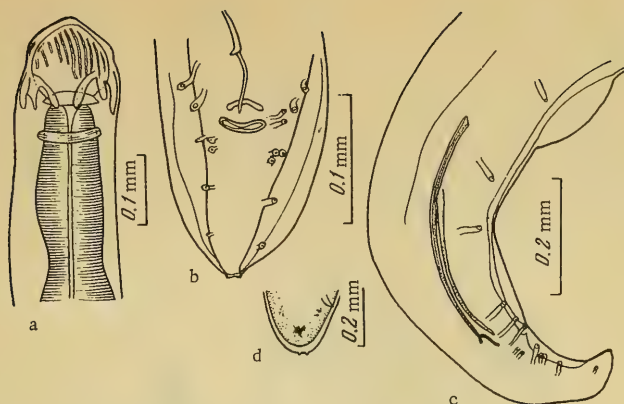


FIGURE 37. *Camallanus thapari* Gupta, 1959:

a - anterior end, lateral; b - caudal end of male, ventral; c - same, lateral;
d - caudal end of female, lateral (after Gupta, 1959).

Female. Length 20.2–27.9 mm, width 0.45–0.60 mm. Cuticle thin, with delicate striation. Dorsoventral width of head 0.18–0.20 mm. Mouth surrounded by 2 lateral and 4 submedian papillae. Buccal capsule with two valves 0.12–0.15 mm long (without posterior ring) and 0.15–0.16 mm wide. Valves with 11 ribs. A large, chitinized ring 0.09–0.1 mm wide at the connection between valves and esophagus. Tridents well developed: median branch 0.035–0.050 mm, lateral branches 0.05–0.06 mm long.

Club-shaped muscular anterior part of esophagus 0.63–0.69 mm long and 0.12–0.15 mm wide, cylindrical glandular posterior part 0.59–0.61 mm long and 0.13–0.15 mm wide.

Nerve ring situated 0.18–0.2 mm from cephalic end. Tail 0.135–0.165 mm long, finger-shaped, with two small cuticular processes at the end. In a specimen about 20.2 mm long the vulva is situated before the middle of the body, 8.2 mm from the cephalic end. Lip of vulva lobelike.

Reference: Gupta, 1959, p. 774.

Camallanus thaparus Sahay and Narayan, 1968 (Figure 38)

Host: *Channa* (*Ophiocephalus*) *striatus*.

Localization: intestine.

Distribution: India.

Description (after Sahay and Narayan, 1968). Thin, threadlike forms, dark red in life, without recognizable cuticular striation. Valves of buccal capsule wider than long in females, but this difference is small in males. Buccal capsule consisting of two valves with two outer thickenings and 9 longitudinal ribs. Cuticular ring situated at connection between valves and esophagus. Esophagus divided into a muscular and a glandular part, the glandular part shorter. Valves are present where the glandular part passes into the intestine.

Tridents distinct, with three branches of different length, their end bluntly pointed.

Male. Length 7.00–7.44 mm, width 0.20–0.22 mm. Buccal valves 79 without the cuticular ring 0.095–0.115 mm long, 0.09–0.110 mm wide. Cuticular ring 0.08–0.09 mm wide. Length of muscular part of esophagus 0.51–0.52 mm, of glandular part 0.41–0.43 mm. Lateral branches of trident 0.06–0.07 mm long, median branch 0.025 mm. Nerve ring situated 0.16–0.18 mm from cephalic end.

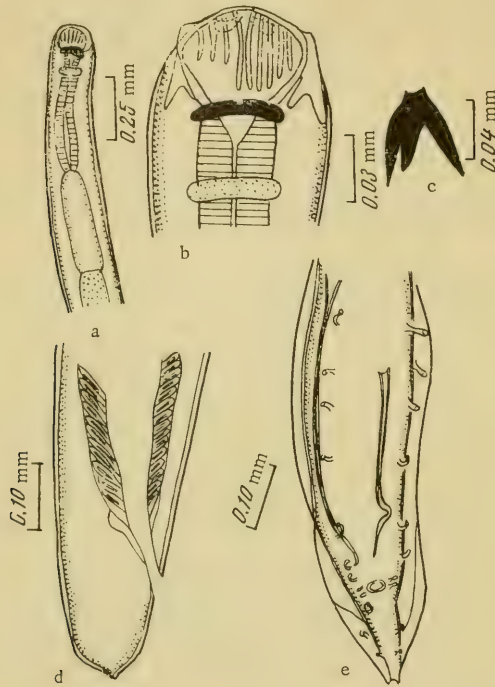


FIGURE 38. *Camallanus thaparus* Sahay and Narayan, 1968:

a - anterior end; b - cephalic end, lateral; c - trident; d - caudal end of female, lateral; e - caudal end of male, ventral (after Sahay and Narayan, 1968).

Caudal end curved ventrally. Tail 0.170–0.183 mm long, conical, ending in two spines. Thirteen pairs of caudal papillae, 7 pairs precloacal, 2 adanal, and 4 pairs postcloacal. The first and second of the 4 postanal pairs are situated behind the cloaca, close together; the other two pairs are spaced at different intervals. Almost all 7 pairs of precloacal papillae are equally spaced except the fifth pair, which is situated 0.10–0.12 mm from the fourth pair. The caudal wings extend slightly beyond the proximal end of the large spicule. Left spicule weakly chitinized, 0.20–0.225 mm long, the right spicule 0.425 mm long. Both spicules pointed.

Female. Length 16.6 mm, maximum width 0.237 mm. Length of buccal valves without cuticular ring 0.13 mm, width 0.16 mm. Cuticular ring 0.115 mm wide. Length of muscular part of esophagus 0.725 mm, of glandular part 0.525 mm. Lateral branches of trident 0.06 mm long, median branch 0.035 mm. Nerve ring situated 0.23 mm from cephalic end.

Tail tapering, with rounded end with two thin, spinelike processes 0.15 mm long. Vulva situated behind middle of body, 5.5 mm from the caudal end, dividing the body at the ratio of 3.2:1. Vagina long and muscular. Oviparous. Eggs present in posterior part of vagina.

Reference: Sahay and Narayan, 1968, pp.118—124.

Camallanus trichogasterae Pearse, 1933 (Figure 39)

Host: *Trichogaster trichopterus*.

Localization: intestine.

Distribution: Asia.

Description (after Pearse, 1933). Dark yellowish brown, opaque forms, with distinct transverse striation. Chitinized valves of buccal capsule with 14—20 ribs.

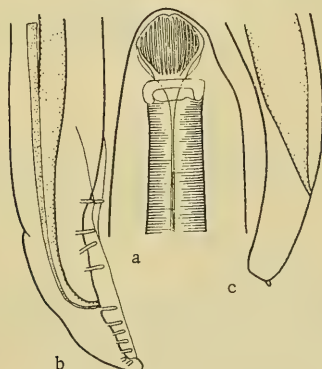


FIGURE 39. *Camallanus trichogasterae* Pearse, 1933:

a — anterior end; b — posterior end of male, lateral; c — posterior end of female, lateral (after Pearse, 1933).

Male. Length 3.55 mm. Tail, 0.07 mm long, blunt, curved ventrally. Five pairs of large postanal papillae and 2 pairs of small papillae at the end of the tail. Four preanal papillae. Length of right spicule 0.36 mm.

Female. Length 7.2 mm. Depth of chitinized buccal capsule 0.09 mm. Length of buccal valves 0.06 mm, of chitinized pharynx 0.03 mm. Length of muscular esophagus 0.4 mm, of glandular part 0.68 mm. Tail 0.12 mm long, blunt, ending in a pair of small spines. Vulva situated at anterior third of body.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 29; Pearse, 1933, pp. 184-185.

Camallanus tridentatus (Drasche, 1884) (Figure 40)

Host: *Arapaima gigas*.

Localization: intestine.

Distribution: Brazil (Amazon Basin).

Description (after Travassos, Artigas, and Pereira, 1928).

Male not known.

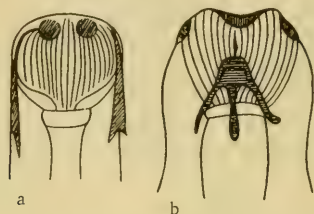


FIGURE 40. *Camallanus tridentatus* (Drasche, 1884):

a — cephalic end, lateral; b — same, dorsoventral (after Travassos, Artigas, and Pereira, 1928).

Female. Length 7.7-10 mm. Buccal capsule with two chitinized valves which are 0.17 mm wide and 0.12 mm long. Valves with 30 ribs. Tridents 0.1 mm long, branches rodlike. Length of esophagus 0.65 mm; length of ventricle 0.75 mm. Vulva situated 3.4 mm from posterior end. Tail 0.15 mm long.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 29; Travassos, Artigas, and Pereira, 1928, p. 20.

Camallanus truncatus (Rudolphi, 1814) (Figure 41)

Synonyms: *Cucullanus truncatus* Rudolphi, 1814; *Camallanus lacustris* Yorke and Maplestone, 1926, nec Zoega, 1776

Hosts: definitive — *Perca fluviatilis*, *Caspialosa brashnikovi*, *Coregonus lavaretus oxyrhynchus*, *Osmerus eperlanus*, *Esox lucius*, *Silurus glanis*, *Lota lota*, *Lucioperca lucioperca*, *Lucioperca volgensis*, *Acerina cernua*, *Rhombus maximus*; intermediate — *Mesocyclops leuckarti*, *Acanthocyclops viridis*.

Localization: intestine.

Distribution: Western Europe, USSR.

Description (after Mészáros, 1967). Branches of tridents extending beyond the middle between buccal capsule and nerve ring.

82 Male. Length 2.7–4.8 mm. Length of buccal capsule 0.078–0.083 mm. Median branch of tridents 0.097–0.10 mm long. Muscular part of esophagus 0.48–0.52 mm long, glandular part 0.45–0.58 mm.

Female. Length 3.80–10.60 mm. Length of buccal capsule 0.077–0.130 mm. Median branch of tridents 0.077–0.13 mm long. Muscular part of esophagus 0.58–0.62 mm long, glandular part 0.62–0.82 mm.

The development of *Camallanus truncatus* was studied by Kupriyanova (1954). The females are viviparous. Larvae discharged into the water with the feces of fish are colorless, 0.429–0.430 mm long, and 0.012–0.013 mm wide. There is no chitinized buccal capsule and the intestinal tract is weakly developed and not differentiated. The tail is long and pointed. Larvae of *C. truncatus* survive 11–12 days in water at 9–10°.

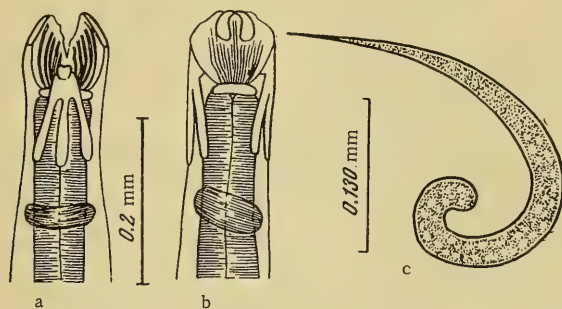


FIGURE 41. *Camallanus truncatus* (Rudolphi, 1814):

a — cephalic end, ventral; b — same, lateral; c — larva from an adult female (a, b — after Mészáros, 1967; c — after Kupriyanova, 1954).

At 18–20°, larvae swallowed by *Cyclops* enter the body cavity after 40 minutes. At 19–21°, larvae of *C. truncatus* undergo the first molt in *Cyclops* after 24–48 hours. The old cuticle is very thin and adheres closely to the new one. Second-stage larvae are 0.430–0.432 mm long and 0.013 mm wide. The caudal end becomes more rounded.

The second molt takes place after 5–6 days. The larvae now have a distinctly chitinized buccal capsule, but tridents are still absent, and they are probably not developed at all in larvae in *Cyclops*, as none were observed even after 32 days in the host. The esophagus is divided into a muscular and a glandular part. The caudal end becomes much shorter and the larvae turn yellowish. Length 0.478–0.489 mm, width 0.015 mm.

If the temperature falls to 7–9°, development of the larvae is markedly retarded: the first molt takes place after 2–3 days and the second after 15 days.

83 Kupriyanova used perch as definitive host. During the first two weeks of development in the perch the larvae increase in body mass without distinct morphological changes. After 10 days larvae of *C. truncatus* are 1.084 mm long and 0.039 mm wide; depth of buccal capsule 0.041 mm, width 0.026 mm; length of anterior part of esophagus 0.182 mm, of posterior part 0.176 mm.

After 20–25 days of development in the definitive host the tridents begin to develop and their development is completed 5–7 days later. The larvae are now 0.117 mm long and 0.010–0.011 mm wide.

Kupriyanova assumed that further development of *C. truncatus* may take place either with an intermediate host or with an intermediate and a reservoir host. In the reservoir host (juveniles of *Leuciscus idus*, *L. leuciscus*, *Abramis brama*, *Perca fluviatilis*) the larvae settle in the intestine, usually in the anterior part; however, they apparently do not develop there.

References: Ivashkin and Khromova, 1964, pp.98–104; Kupriyanova, 1954, pp.373–377; Sobolev, 1962, pp.270–274; Mészáros, 1967, p. 159.

Camallanus wolgensis Lewaschow, 1929 (Figure 42)

Host: *Pelecus cultratus*.

Localization: intestine.

Distribution: USSR (Lower Volga).

84 Description (after Lewaschoff, 1929). Buccal capsule with dark lateral valves, with 15–17 longitudinal ribs. After a short constriction, the posterior end of the valves forms a widening (thickening). The two thickenings form a chitinized ring. 0.05 mm wide before the esophagus. Tridents strongly chitinized, 0.065 mm long. Four well-developed submedian papillae at the anterior end. Esophagus divided into a muscular anterior and a glandular posterior part. The muscular part of the esophagus was 0.52 mm long and the glandular 0.45 mm in one specimen. Three large nuclei present in the posterior part of the esophagus. Several large cells with distinct nuclei around the rectum.

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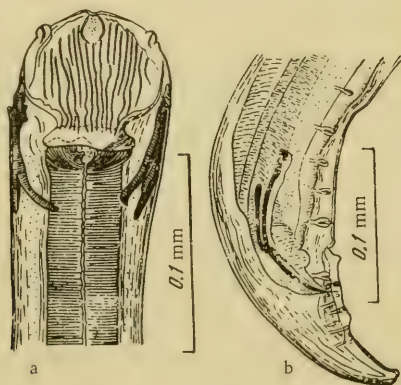


FIGURE 42. *Camallanus wolgensis* Lewaschow, 1929:
a — cephalic end, lateral; b — posterior end of male, lateral
(after Lewaschoff, 1929).

Male. Length 1.58 mm, width of cephalic end in the middle of the valves 0.075 mm, maximum width 0.077 mm, at the anus 0.047 mm. Tail 0.083 mm long. Caudal wings present; 6 pairs of preanal, 2 pairs of paranal, and

3 pairs of postanal papillae. Spicules 0.14 and 0.08 mm long. The spicules have a sheath. Gubernaculum absent.

Female. Length of immature specimen 2.78 mm, width at the buccal capsule 0.127 mm, at the vulva 0.067 mm. Length of esophagus 0.97 mm. Tail 0.15 mm long, its end pointed and skittle-shaped. Vulva situated 1.77 mm from cephalic end.

Tridents, which are present in adults, are absent in young specimens.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 29; Lewaschoff, 1929, pp. 123–126.

***Camallanus yehi* Fernando and Furtado, 1963 (Figure 43)**

Host: *Channa* (*Ophiocephalus*) *striatus*.

Localization: intestine.

Distribution: Singapore.

Description (after Fernando and Furtado, 1963a). Lateral valves of buccal capsule with 18 longitudinal ribs without armature. Buccal capsule sclerotized, pharynx also sclerotized. Glandular esophagus straight. There is a pair of small, rudimentary tridents in males; in females they are represented by a small rod.

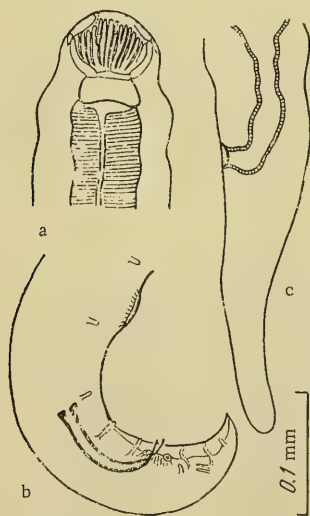


FIGURE 43. *Camallanus yehi* Fernando and Furtado, 1963:

a — cephalic end, lateral; b — caudal end of male, lateral; c — caudal end of female, lateral (after Fernando and Furtado, 1963a).

Male. Length 5.76–6.10 mm, width 0.120 mm. Buccal capsule 0.056 mm long and 0.085 mm wide. Pharynx 0.022 mm long, maximum width 0.059 mm. Muscular part of esophagus 0.252 mm long, 0.096 mm wide, glandular part of

85 esophagus 0.720 mm long, 0.160 mm wide. Nerve ring surrounding muscular part of esophagus 0.096 mm from its beginning, 0.163 mm from the anterior end. Tail conical, curved ventrally, ending in a pointed process. Cloaca situated 0.096 mm from end of tail. Six pairs of preanal papillae (one pair slightly before the cloaca) and 7 pairs of postanal papillae, one pair slightly behind the cloaca. Two equal, weakly chitinized spicules 0.110 mm long.

Female. Length 7.2–10.5 mm, width 0.240 mm. Buccal capsule 0.056–0.059 mm long, 0.074–0.082 mm wide. Sclerotized pharynx 0.026 mm long and 0.059 mm wide. Muscular part of esophagus 0.320 mm long, 0.096 mm wide, glandular part of esophagus 0.640–0.800 mm long, 0.122–0.128 mm wide. Nerve ring surrounding muscular part of esophagus 0.085–0.093 mm from its beginning, 0.166–0.185 mm from the cephalic end. Tail conical, with rounded end. Anus situated 0.240–0.315 mm from end of tail. Vulva situated slightly before middle of body, dividing it at the ratio of 1:1.1–1:1.5.

Reference: Fernando and Furtado, 1963a, pp. 59–61.

Camallanus zacconis Li, 1941 (Figure 44)

Host: *Zacco temminckii*.

Localization: large intestine.

Distribution: China.

Description (after Li, 1941). Cuticle smooth, Buccal capsule consisting of two valves with 17–18 longitudinal ribs. Cuticular ring situated at the connection between the buccal capsule and the esophagus. Tridents with three branches of equal length. There are two small tetragonal chitinized plates at the anterior margin of the buccal valves. Cephalic papillae forming two rings. Inner ring consisting of 6 small papillae, the outer of 4 papillae and 2 amphids. Glandular part of esophagus slightly longer than muscular part; nerve ring situated at the anterior quarter of the muscular part of the esophagus.

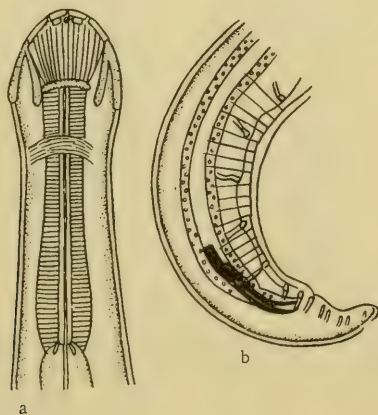


FIGURE 44. *Camallanus zacconis* Li, 1941:

a — anterior end, lateral; b) caudal end of male, lateral
(after Li, 1941).

Male. Length 3.15–3.35 mm, width 0.16–0.18 mm. Buccal capsule 0.09–0.11 mm long, 0.1–0.11 mm wide. Cuticular ring 0.5–0.6 mm wide. Nerve ring situated 0.145–0.170 mm from cephalic end. Muscular part of esophagus 0.315–0.330 mm long, glandular part 0.35–0.37 mm.

Caudal wings narrow. Right spicule markedly longer and thicker than the left, 0.12–0.145 mm long and 0.007 mm wide. Left spicule 0.08–0.093 mm long, 0.004 mm wide. Seven pairs of precloacal, 2 pairs of paracloacal, and 6 pairs of postcloacal papillae. The postcloacal papillae are sometimes divided into three groups: an anterior group of three pairs, a middle group of two pairs, and the posterior pair is isolated. Tail short, 0.081–0.086 mm long, with blunt end.

Female. Length 3.65–3.75 mm, width 0.14–0.16 mm. Buccal capsule 0.12 mm long, 0.12–0.13 mm wide. Cuticular ring 0.080–0.13 mm wide. Nerve ring situated 0.19–0.24 mm from cephalic end. Muscular part of esophagus 0.41–0.44 mm long, glandular part 0.45–0.47 mm. Vulva situated in posterior part of body, 1.52 mm from the caudal end, protruding above the surface, dividing the body at the ratio of 1:0.71 or 1.4:1.

The uterus contained eggs at the morula stage. Tail 0.55 mm long, thin, with blunt end.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 29; Li, 1941, pp. 195–199.

Camallanus sp. Chatterji, 1936

Host: *Morenia ocellata*.

Localization: intestine.

Distribution: Burma.

Description (after Baylis, 1939).

Male not known.

Female. Length 11.2 mm. Buccal valves wider than long, with 10 longitudinal ribs. Vulva situated before middle of body, with protruding anterior lip.

Note. The description is made of one immature female. According to Yeh (1960b), reptiles are not typical hosts of the genus *Camallanus*. However, the genus of this form cannot be determined because of the inadequate description. We place it therefore provisionally in the genus *Camallanus*, in which it was described.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 28; Baylis, 1939, p. 214; Chatterji, 1936, p. 81.

Camallanus sp. Kung, 1948 (Figure 45)

Host: bull frog.

Localization: intestine.

Distribution: South Africa.

Description (after Kung, 1948).

Male not known.

Female (young specimen). Length 2.72 mm, width 0.184 mm. Body narrowing posteriorly from the middle, cuticle distinctly transversely striated. Buccal capsule 0.121 mm deep, maximum width 0.172 mm. Lateral valves

with 29–32 longitudinal ribs. Mouth surrounded by 6 cephalic papillae, four submedian and two lateral. Tridents about 0.079 mm long, not reaching anterior part of esophagus. Nerve ring situated 0.20 mm, cervical papillae 0.32 mm from cephalic end. Length of esophagus 0.86 mm, length of muscular anterior part 0.39 mm. Vulva protruding above the surface, situated 1.69 mm from the cephalic end. Vagina about 0.248 mm long. Uterus incompletely filled with larvae. Tail 0.135 mm long, ending in three processes.

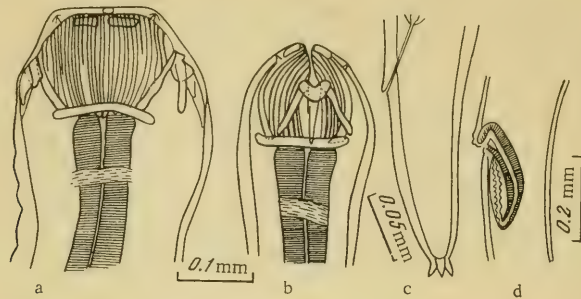


FIGURE 45. *Camallanus* sp. Kung, 1948:

a, b — cephalic end, different aspects; c — caudal end of female, lateral, d — region of vulva, lateral (after Kung, 1948).

Reference: Kung, 1948, pp.103–106.

Camallanus sp. Liu and Wu, 1941 (Figure 46)

Host: *Macrone longirostris*.

Localization: stomach.

Distribution: China.

Description (after Liu and Wu, 1941).

Male not known.

Female. Length 4.88 mm, width 0.2 mm. Length of esophagus 1.1 mm, width 0.1 mm. Head oblong, mouth dorsoventral, slitlike. Two lateral amphids and 4 pairs of submedian papillae, the two pairs near the corners of the mouth larger. Valves of buccal capsule with 15–17 longitudinal ribs. Dorsal and ventral to each amphid is an area of thickened cuticle, the anterior part of which passes into the valve; its posterior margin is distinctly separated from the valve. The buccal capsule is not chitinized behind the valves. A cuticular collar around the connection between buccal capsule and esophagus. Length of buccal valves 0.131 mm. Intervals between longitudinal ribs 0.007 mm. Intervals of striation of cuticle 0.0048 mm.

88 Esophagus consisting of two parts, the glandular part longer. Trident well developed. Median branch 0.112 mm long. Vulva situated slightly before posterior third of body, 1.87 mm from posterior end. Tail 0.69 mm long, with rounded end. Larvae hatching in the uterus.

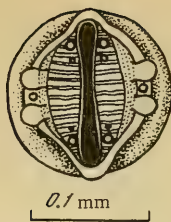


FIGURE 46. *Camallanus* sp. Liu and Wu, 1941:

Cephalic end, apical (after Liu and Wu, 1941).

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.28; Liu and Wu, 1941, pp.67–72.

Camallanus sp. Moorthy, 1938 (Figure 47)

Hosts: *Barbus puckelli*, *Lepidocephalichthys thermalis*, *Ophiocephalus gachua*.

Localization: body cavity, intestine (free and encysted).

Distribution: India.

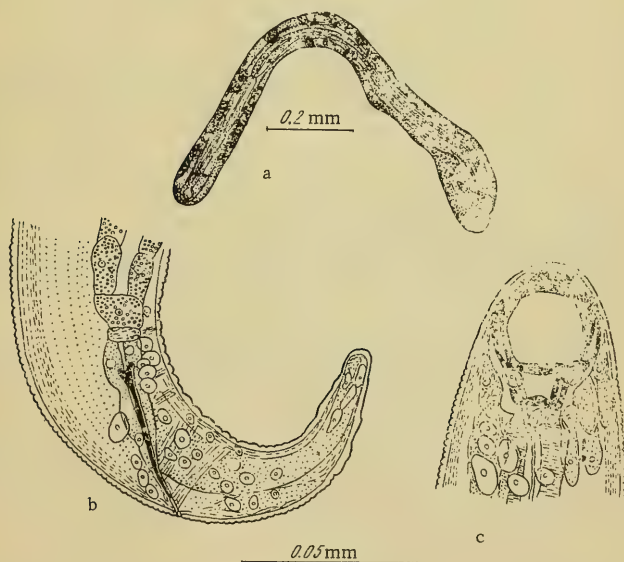


FIGURE 47. *Camallanus* sp. Moorthy, 1938:

a — encysted larva from intestine of *O. gachua*; b — caudal end of encysted larva; c — cephalic end of encysted larva (after Moorthy, 1938b).

Description (after Moorthy, 1938b). Length of larva 1.1–1.6 mm, width 0.05–0.06 mm. Stoma 0.035–0.048 mm deep. Buccal capsule narrow,

half as long as in the third-stage larva; longitudinal ribs absent. Two
89 pairs of papillae in the outer ring. Amphids present at anterior margin
of body, between two pairs of chitinized tetragonal plates. Esophagus con-
sisting of a muscular anterior part 0.19–0.22 mm long and a glandular
posterior part 0.16–0.22 mm long. Nerve ring situated 0.09–0.11 mm from
cephalic end. Excretory pore situated slightly behind the nerve ring. In-
testine consisting of 100–120 cells arranged in transverse rows, 3–4 cells
in each row. Anus situated 1.0–1.5 mm from anterior end. Tail 0.063–
0.081 mm long, conical, without processes.

References: Baylis, 1939, p.214; Moorthy, 1938b, pp.335–336.

Camallanus sp. Moorthy, 1938

Host: *Mesocyclops leuckarti*.

Localization: body cavity.

Distribution: India.

Description (after Moorthy, 1938b). Larva 1.09 mm long and 0.07 mm
wide. Stoma 0.046 mm deep, consisting of an almost completely chitinized
buccal capsule and distinct buccal valves with 14 longitudinal ribs of dif-
ferent length. They extend from the cephalic end to the chitinous ring behind
the buccal capsule. Two pairs of papillae in the outer ring. Amphids situa-
ted between two pairs of chitinized tetragonal plates. Cuticle deeply trans-
versely striated with intervals of about 0.004 mm. Muscular anterior part of
esophagus 0.26 mm long, glandular posterior part 0.14 mm; boundary between
the two parts distinct. Nerve ring situated 0.13 mm from cephalic end.
Excretory pore situated slightly behind the nerve ring. Nucleus of ex-
cretory cell situated at the base of the muscular part of the esophagus.
Intestine consisting of 65 cells arranged in transverse rows, 3–4 cells in
each row. Genital primordium situated 0.72 mm from anterior end, consisting
of 4 longitudinally arranged cells.

Anus situated 1.05 mm from anterior end. Phasmids rounded, situated
slightly behind the anus. Tail 0.46 mm long. Three spines of equal length
at end of tail.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and
Sudarikov, 1954, p.28; Baylis, 1939, p.214; Moorthy, 1938b, p.323.

Camallanus sp. Vuylsteke, 1964 (Figure 48)

Host: fish.

Localization: intestine.

Distribution: Central Africa.

Description (after Vuylsteke, 1964).

Male not known.

Female. Length 10 mm, maximum width 0.315 mm. Buccal capsule
0.092 mm long. Length of esophagus 0.700 mm. Genital opening situated
90 4.200 mm from cephalic end. Vagina directed posteriorly, uterus diverging.
Larvae, twisted, were found free at the end of the body. Tail with three
small pointed processes at the end.

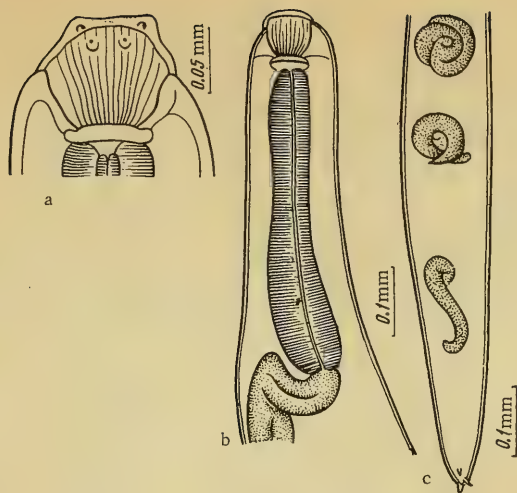


FIGURE 48. *Camallanus* sp. Vuylsteke, 1964:

a — cephalic end; b — anterior end; c — posterior end of female (after Vuylsteke, 1964).

Reference: Vuylsteke, 1964, p. 58.

Genus *Camallanides* Baylis and Daubney, 1922

Historical review

The genus *Camallanides* was established for the species *Camallanides prashadi*, which was the only species of the genus for a long time. Khera (1954) described *C. piscatori* and *C. ptyas*, and established the two subgenera *Camallanides* and *Procamallanides*. The validity of the new subgenera because of the presence or absence of dorsal and ventral chitinous bodies in the buccal capsule is doubtful. Campana-Rouget (1961a) and Deshmukh (1968) think that division of the genus *Camallanides* into subgenera is not justified.

Gupta (1959) found one female of *Camallanides* in Pakistan, the description of which we give as *Camallanides* sp. Yamaguti (1967b) placed "*Camallanus bungari*" MacCallum, 1918 in this genus with a question mark.

Diagnosis. *Camallaninae*. Buccal capsule with thickened lateral walls, with ribs on the inside. The lateral walls of the buccal capsule have two longitudinal massive reddish brown thickenings on the outside which are separated by a longitudinal groove in the middle. Outside the dorsal and ventral part of the buccal capsule are rodlike formations which may be homologues of the tridents characteristic of the genus *Camallanus*.

There is a cuticular ring at the base of the buccal capsule. The esophagus consists of a muscular anterior part and a glandular posterior part. Cervical papillae small, setalike.

Male. Caudal wings present, supported by 14 pairs of pedunculate papillae, seven pairs of them preanal. Right spicule longer and more massive than the left; it has wings and a hooklike distal end. Gubernaculum present.

Female. Vulva with a tubular, posteriorly directed appendage situated before middle of body. Posterior uterus without an ovary.

Parasites of the intestinal tract of snakes and frogs.

Type species: *Camallanides prashadi* Baylis and Daubney, 1922.

Camallanides prashadi Baylis and Daubney, 1922
(Figure 49)

Hosts: *Naja hannah*, *Bungarus fasciatus*, *Ptyas* (*Zamenis*) *mucosus*, *Rana tigrina*.

Localization: intestine.

Distribution: India.

Description (after Baylis, 1939). Cuticular striation very fine and indistinct, with intervals of 0.003–0.004 mm. The buccal valves appear like four separate cuticular formations. Each valve has two wide outer thickenings with a longitudinal groove; 14 longitudinal ribs on the inside which end anteriorly in toothlike appendages. Tridents absent, but there are yellow rodlike formations which are sometimes of irregular form. They are connected with the chitinous base on the dorsal and ventral sides at the margins of the valves.

Male. Length 5.8–6.6 mm, width 0.21–0.25 mm. Dorsoventral width of cephalic end 0.08–0.09 mm. Length of buccal valves 0.06 mm, width 0.075 mm. Length of rodlike formations 0.06 mm. Posterior ring of buccal apparatus 0.033 mm wide. Anterior part of esophagus 0.38 mm long, length of esophagus 0.8 mm. Nerve ring situated 0.15 mm, excretory pore 0.25 mm, and the small, seta-shaped cervical papillae 0.28 mm from the cephalic end.

Caudal wings well developed. Tail about 0.06 mm long, pointed and usually curved ventrally, its end covered by the wings. Caudal papillae pedunculate, decreasing in size posteriorly. The 7 pairs of preanal and the 2 pairs of adanal papillae are curved ventrally, while the 5 pairs of postanal papillae are situated laterally. The first three pairs are larger and situated close together. Right spicule massive, 0.24 mm long, with wings almost its entire length. Its end is hooked. Left spicule without wings, thin and pointed, about 0.14 mm long. Gubernaculum nearly triangular, about 0.025 mm long.

93 Female. Length 14.2–17.7 mm, width 0.40–0.47 mm. Dorsoventral width of cephalic end 0.12–0.13 mm. Length of buccal valves 0.09–0.1 mm, width 0.1 mm. Length of rodlike formations 0.07–0.1 mm. Posterior ring of buccal apparatus 0.045 mm wide. Anterior part of esophagus 0.47–0.50 mm long, length of esophagus 1.0 mm. Nerve ring situated 0.19 mm, excretory pore 0.31 mm, and the small, seta-shaped cervical papillae 0.35 mm from the cephalic end.

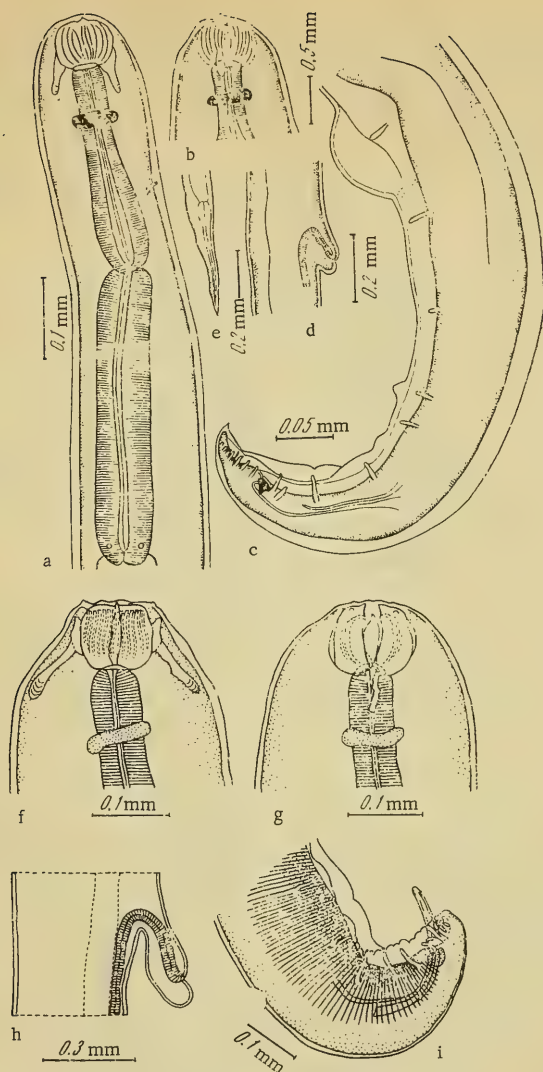


FIGURE 49. *Camallanides prashadi* Baylis and Daubney, 1922:

a — anterior end of male, lateral; b — cephalic end, ventral; c — posterior end of male, lateral; d — region of vulva, lateral; e — caudal end of female, lateral; f, g — cephalic end, different aspects; h — region of vulva, lateral; i — caudal end of male, lateral (a — e — after Agrawal, 1967; f — i — after Baylis and Daubney, 1922).

The lips of the vulva form a tubular appendage which is sometimes dorsoventrally flattened and projects free posteriorly for 0.3–0.4 mm. The appendage is situated at the anterior third of the body, 5.9–6.1 mm from the cephalic end. The vulva is situated on the ventral surface of the appendage, near its end. Vagina narrow, extending posteriorly for about 2 mm. Posterior branch of uterus without an ovary. Tail 0.4–0.6 mm long, tapering, slightly thickened before the conical end.

Description (after Agrawal, 1967). Nematodes of medium size, slender, markedly truncate at both ends. Cuticle thin, with delicate striation. Mouth dorsoventral, surrounded by 6 papillae. Buccal capsule consisting of two valves, which consist of two chitinoid formations separated by a wide longitudinal groove. Valves with 10–12 complete and incomplete longitudinal ribs in both sexes. A large, chitinized ring at the connection between valves and esophagus. Tridents simple, pointed, yellow, situated opposite the corners of the buccal valves. Dorsal and ventral chitinoid formations 0.10–0.15 mm long.

Male. Length 6.74–7.29 mm, width 0.24–0.28 mm. Dorsoventral width of cephalic end 0.08–0.09 mm. Length of buccal capsule 0.06–0.065 mm, width 0.080–0.085 mm. Chitinoid ring 0.040–0.042 mm wide. Tridents 0.065–0.075 mm long. Length of club-shaped muscular anterior part of esophagus 0.29–0.30 mm, width 0.075–0.080 mm, length of cylindrical glandular posterior part 0.42 mm, width 0.09–0.095 mm. Length of esophagus 0.71–0.72 mm. Nerve ring surrounding anterior part of esophagus, situated 0.14 mm, excretory pore 0.19–0.22 mm from cephalic end.

Tail conical, pointed, curved ventrally, forming a ring, 0.06–0.09 mm long. Caudal wings beginning at the cuticular thickening on the ventral side and extending to end of tail.

Fourteen pairs of caudal papillae: 7 preanal, 2 paracloacal, and 5 postanal pairs. The papillae are pedunculate, riblike, and decrease in size posteriorly. Preanal papillae almost equally spaced. Paracloacal papillae curved inward and ventrally. Postanal papillae forming three groups. Right spicule 0.29–0.36 mm long, its end curved in a hook. Left spicule, slender, markedly truncate, 0.175–0.190 mm long. Gubernaculum yellow, triangular, 0.028–0.029 mm long.

Female. Length 13.56–19.88 mm, width 0.40–0.48 mm. Dorsoventral width of cephalic end 0.11–0.14 mm. Length of buccal capsule 0.08–0.115 mm, width 0.11–0.14 mm. Chitinoid ring 0.055–0.070 mm wide. Length of muscular anterior part of esophagus 0.31–0.40 mm, width 0.10–0.15 mm, length of glandular posterior part 0.51–0.63 mm, width 0.10–0.15 mm. Length of esophagus 0.88–0.99 mm. Nerve ring situated 0.18–0.26 mm, excretory pore 0.32–0.56 mm, cervical papillae 0.52–0.86 mm from cephalic end.

Tail 0.29–0.36 mm long, tapering, with a slight widening before the end. Vulva forming a tubular process which is dorsoventrally flattened and projects free, situated 6.1–8.6 mm from the cephalic end.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 35; Agrawal, 1967, pp. 338–341; Baylis, 1939, p. 274; Baylis and Daubney, 1922, pp. 263–347.

Camallanides bungari (MacCallum 1918) Yamaguti, 1961
(Figure 50)

Host: *Bungarus candidus*.

Localization not given.

Distribution: Java.

Description (after MacCallum, 1918).

Male not known.

Female. Mouth wide, subterminal. Opening of esophagus with two rings, the outer ring with small teeth. The rounded anterior margin of the esophagus is covered with small denticles. Esophagus bottle-shaped and muscular. Vulva situated at posterior third of body. Tail pointed, with three spines.

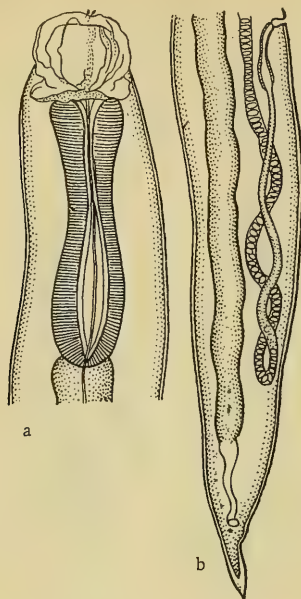


FIGURE 50. *Camallanides bungari* (MacCallum, 1918):

a — anterior end; b — posterior end of female, lateral (after MacCallum, 1918).

References: MacCallum, 1918, pp.123—124; Yamaguti, 1961a, pp.217—228.

95 *Camallanides dhamini* Deshmukh, 1968 (Figure 51)

Host: *Ptyas mucosus*.

Localization: intestine.

Distribution: India.

Description (after Deshmukh, 1968). Thin, red nematodes. Cuticle not striated. Head with 6 papillae, four submedian and two lateral. A group of esophageal glands at the base of the buccal capsule. Anterior part of esophagus club-shaped and muscular.

Male. Length 5.5 mm, width 0.22 mm. Buccal capsule 0.086×0.071 mm large. Capsule with 14 ribs. Length of posteriorly directed rods 0.064 mm. Buccal ring 0.043 mm wide. Nerve ring situated 0.15 mm from cephalic end. Length of anterior part of esophagus 0.29 mm, of posterior part 0.37 mm.

Caudal wings 1.10 mm long and 0.24 mm wide. Fifteen pairs of pedunculate caudal papillae, 7 pairs precloacal, regularly distributed. The 5 pairs of postcloacal papillae are situated just behind the cloaca. Behind this group is a pair of double papillae, two papillae situated almost on the same base. Another pair of papillae situated in the middle between end of tail and the double pair of papillae. Spicules 0.31 and 0.26 mm long. Gubernaculum 0.017 mm long and 0.016 mm wide. Tail 0.13 mm long.

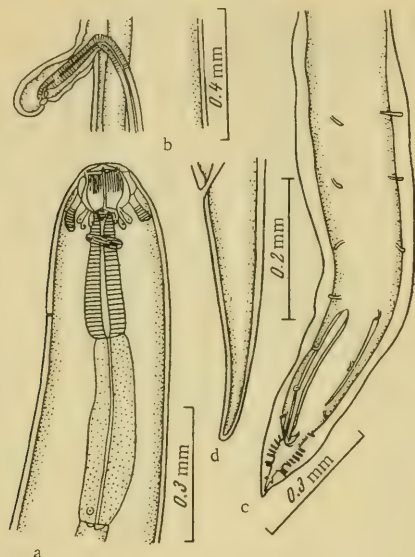


FIGURE 51. *Camallanides dhamini* Deshmukh, 1968:

a — anterior end, lateral; b — region of vulva, lateral; c — caudal end of male, ventral; d — caudal end of female, lateral (after Deshmukh, 1968).

Female. Length 11.3–14.76 mm, width 0.30–0.39 mm. Buccal capsule 0.105×0.090 mm large, with 16 ribs. Length of posteriorly directed rods 0.086 mm. Buccal ring 0.048 mm wide. Nerve ring situated 0.15–0.17 mm from cephalic end. Length of anterior part of esophagus 0.28–0.31 mm, of posterior part 0.43–0.46 mm. The tubular vagina projects posteriorly in the form of an appendage 0.33 mm long. This appendage is situated 4.93–5.74 mm from the cephalic end. Larvae 0.49 mm long and 0.018 mm wide.

Reference: Deshmukh, 1968, pp.119–122.

96 *Camallanides hemidentata* Majumdar, 1965 (Figure 52)

Host: *Channa* (*Ophiocephalus*) *striatus*.

Localization: intestine.

Distribution: India.

Description (after Majumdar, 1965). Cuticle finely transversely striated. Buccal capsule formed by two lateral valves, each valve with 11

longitudinal ribs. Tridents reduced to rods. Cephalic and cervical papillae absent. Esophagus divided into a long, muscular, club-shaped anterior part and a shorter glandular posterior part.

Male. Length 2.62–3.48 mm, width 0.13–0.16 mm. Length of buccal valves 0.03–0.04 mm, width 0.05 mm. Length of trident 0.013 mm. Nerve ring situated 0.10–0.11 mm from cephalic end. Length of muscular part of esophagus 0.24–0.28 mm, width 0.06 mm, length of glandular part 0.40–0.53 mm, width 0.09–0.10 mm.

Tail curved ventrally, 0.06–0.09 mm long. Caudal wings extending to end of tail. Six pairs of caudal papillae, five pairs postanal and one pair preanal. Left spicule 0.13–0.18 mm long, right spicule 0.11–0.13 mm long. Gubernaculum absent.

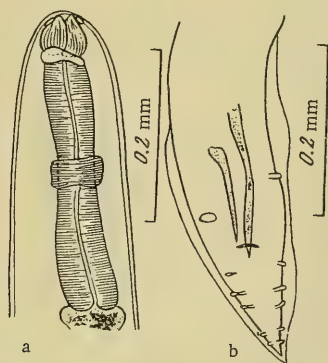


FIGURE 52. *Camallanides hemidentata* Majumdar, 1965:

a — anterior end; b — caudal end of male, ventral (after Majumdar, 1965).

Female. Length 5.92 mm, width 0.22 mm. Length of buccal valves 0.05 mm, width 0.06 mm. Length of trident 0.013 mm. Nerve ring situated 0.22 mm from cephalic end. Length of muscular part of esophagus 0.29 mm, width 0.09 mm, length of glandular part 0.55 mm, width 0.11 mm. Tail long, 0.29 mm, conical. Vulva protruding above the surface, situated in anterior half of body, 3.45 mm from caudal end. Vagina directed anteriorly. Uterus opposite, filled with larvae. Larvae 0.104 mm long.

Reference: Majumdar, 1965, pp.222–225.

97 *Camallanides piscatori* Khera, 1954 (Figure 53)

Host: *Natrix piscator*.

Localization: intestine.

Distribution: India.

Description (after Khera, 1954). Nematodes of medium length. Cuticle finely striated with intervals of 0.0035–0.006 mm. Mouth dorso-ventral, surrounded by 6 papillae. Buccal capsule consisting of two valves, appearing like four separate reddish brown formations. Each valve consists of

two chitinoid formations separated by a wide longitudinal groove. Valves with 12 complete and incomplete longitudinal ribs. Tridents represented by simple, yellow, pointed chitinoid rods which are sometimes of irregular form; they are attached to the valves. Esophagus divided into a club-shaped muscular anterior part and a cylindrical glandular posterior part. Three small valves at the connection of the esophagus with the intestine. Intestine wider than the posterior part of the esophagus and with a wide lumen. Cells of intestine with a distinct nucleus and granular protoplasm. Rectum small, narrow and lined with cuticle. Three oval rectal glandular cells with large nuclei at the connection between intestine and rectum.

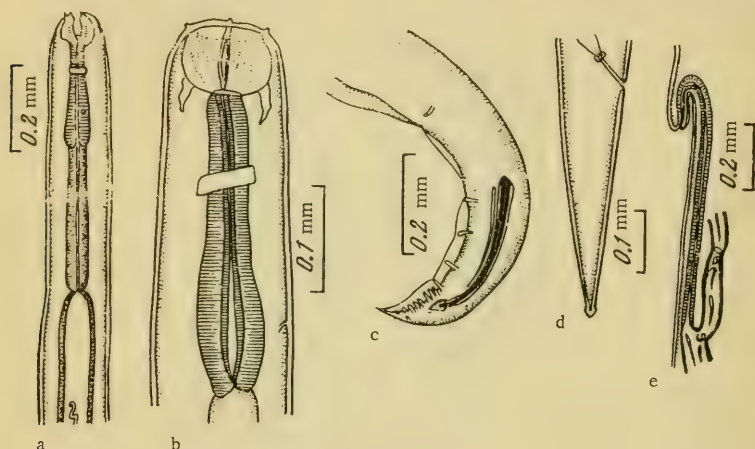


FIGURE 53. *Camallanides piscatoris* Khera, 1954:

a — anterior end, ventral; b — same, lateral; c — caudal end of male, lateral; d — caudal end of female, lateral; e — genital system of female (after Khera, 1954).

Male. Length 5–7 mm, width 0.18 mm. Dorsoventral width of cephalic end at the anterior corners 0.77 mm. Length of buccal valves 0.075 mm, width 0.093 mm. Length of tridents 0.048 mm. Posterior ring of buccal apparatus 0.09 mm wide. Length of esophagus 0.71 mm (anterior part 0.31 mm, 98 posterior part 0.4 mm). Nerve ring situated 0.115 mm, excretory pore 0.3 mm, and the small, seta-shaped cervical papillae 0.28 mm from the cephalic end.

Caudal wings well developed. Tail conical, pointed, 0.12 mm long. Caudal papillae pedunculate and mushroom-shaped, decreasing in size toward end of tail. Fourteen pairs of caudal papillae, 5 pairs precloacal and 9 pairs postcloacal. The anterior pair of precloacal papillae is situated near the beginning of the caudal wings. The four posterior pairs of postcloacal papillae are equally spaced. The postcloacal papillae form three groups of three papillae. All caudal papillae are ventral except the third pair from the posterior end, which is lateral. Right spicule thick and with a wing its entire length, 0.32 mm long. Its proximal end is conical and ends in a pointed process. Left spicule without a wing, thin and pointed, 0.22 mm long. Gubernaculum triangular, 0.025 mm long.

Female. Length 15–17.1 mm, width near the vulva 0.5–0.55 mm. Dorsoventral width of cephalic end at the anterior corners 0.114 mm. Length of buccal valves 0.1–0.11 mm, width 0.135–0.142 mm. Tridents 0.096 mm long. Posterior ring of buccal apparatus 0.04 mm wide. Length of esophagus 0.93–0.99 mm (anterior part 0.36–0.39 mm, posterior part 0.58–0.62 mm). Rectum 0.08 mm long. Nerve ring situated 0.245 mm, excretory pore 0.38 mm, and the small, seta-shaped cervical papillae 0.35 mm from the cephalic end.

Tail 0.42–0.48 mm long, tapering, with a small thickening before the conical end. The lips of the vulva form a tubular process which is dorsoventrally flattened and projects posteriorly for 0.12–0.16 mm. In a specimen 15.6 mm long this process is situated 6.5 mm from the cephalic end. The muscular vagina opens at the base of the process and then extends posteriorly for 0.9 mm along the ventral wall of the body. Uteri opposite. Posterior branch of uterus without an ovary. The single ovary is situated near the anterior end of the intestine. Viviparous. Uteri filled with larvae, which are 0.12–0.15 mm long.

References: Campana-Rouget, 1961a, p. 28; Khera, 1954, pp. 55–58.

Camallanides ptyas Khera, 1954 (Figure 54)

Host: *Ptyas mucosus*.

Localization: intestine.

Distribution: India.

Description (after Khera, 1954). Medium-sized nematodes. Cuticle with delicate striation. Mouth rounded, with 6 papillae: four submedian and two lateral. Buccal apparatus consisting of two reddish brown chitinous valves separated by a wide longitudinal groove. Valves with 10–12 complete and incomplete longitudinal ribs (12 in females, 10–12 in males). The anterior end of the ribs is markedly widened in females. Tridents or "rods" yellowish brown, simple, straight, chitinous, rounded or blunt at both ends. They are attached to the corners of the valves, where there are no dorsal and ventral chitinous bodies. Esophagus divided into a club-shaped muscular anterior part and a cylindrical glandular posterior part. Esophagus connected with the intestine by three small valves. Intestine wider than the posterior part of the esophagus, with a wide lumen. Cells of intestine with granular protoplasm and small nuclei. Rectum small, 0.1 mm long (in female), very narrow. Three nuclear rectal glandular cells at the connection between intestine and rectum.

Male. Length 8.5–8.8 mm, width 0.25–0.29 mm. Dorsoventral width of cephalic end 0.07–0.085 mm. Length of buccal valves 0.062–0.066 mm, maximum width 0.07–0.075 mm. Length of tridents 0.055–0.058 mm. Posterior ring of buccal capsule 0.028 mm wide. Length of esophagus 0.725–0.76 mm (anterior part 0.255–0.27 mm, posterior part 0.47–0.49 mm). Cuticle striated with intervals of 0.002–0.0035 mm. Nerve ring surrounding anterior part of esophagus 0.13–0.15 mm, excretory pore situated 0.3 mm, and the small cervical papillae 0.24 mm from the cephalic end.

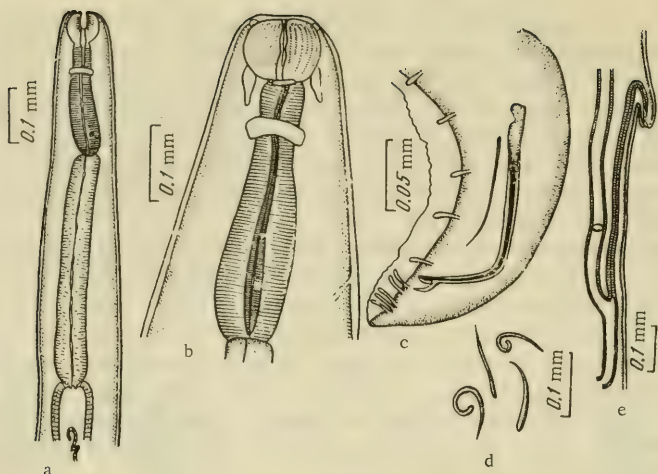


FIGURE 54. *Camallanides ptyas* Khera, 1954:

a — anterior end, ventral; b — same, lateral; c — caudal end of male, lateral; d — larvae; e — genitalia of female (after Khera, 1954).

Caudal wings well developed. Tail conical, pointed, 0.048–0.050 mm long, curved ventrally. Caudal papillae large and pedunculate. Five pairs of precloacal papillae; the first three pairs are lateral. The two posterior pairs of precloacal papillae and all postcloacal papillae are ventral. All papillae of the same size. Right spicule thick, with wings on a large part, 0.19–0.21 mm long and with hooked end. Left spicule weakly chitinized, threadlike, without wings, 0.09–0.1 mm long. Gubernaculum L-shaped, 0.028 mm long.

Female. Length 23–25 mm, width 0.42–0.46 mm. Width of cephalic end at the anterior corners 0.09–0.1 mm. Length of buccal valves 0.09 mm, maximum width 0.11–0.125 mm. Length of tridents 0.075 mm. Posterior ring of buccal capsule 0.045 mm wide. Length of esophagus 1.06–1.16 mm (anterior part 0.36–0.395 mm, posterior part 0.7–0.765 mm). Nerve ring surrounding anterior part of esophagus 0.16–0.17 mm, excretory pore situated 0.42 mm, and the small cervical papillae 0.4 mm from the cephalic end. Cuticle striated with intervals of 0.003–0.005 mm.

Tail 0.46–0.5 mm long, tapering, with a small thickening before the end. Lips of vulva forming a tubular process which is dorsoventrally flattened and extends posteriorly. Length of process 0.3 mm. In a specimen 25 mm long the process is situated 11 mm from the cephalic end. Vulva situated on the ventral surface of the process, near its end. Vagina narrow, extending to the base of the process and then posteriorly for 1.4 mm. Uteri opposite. A single ovary, situated near the anterior end of the intestine. Posterior branch of uterus without an ovary. Viviparous. Uteri filled with small larvae with pointed tail. Larvae 0.10–0.12 mm long.

Reference: Khera, 1954, pp.110–114.

Camallanides sp. Gupta, 1959 (Figure 55)

Host: *Hydrophis cyanocinctus*.

Localization: small intestine.

Distribution: Pakistan.

Description (after Gupta, 1959).

Male not known.

Female (one specimen). Length 10.4 mm, width 0.4 mm. Cuticle thin, with delicate striation. Mouth dorsoventral, with 3 papillae on each side. Buccal capsule with two valves, which consist of two chitinized masses separated by a wide longitudinal groove. Length of buccal capsule 0.1 mm, width 0.11 mm. Valves with 12 complete and incomplete longitudinal ribs. Tridents represented by simple, pointed, chitinized rods of irregular form, with a dorsal and a ventral chitinoid body situated opposite the anterior margin of the buccal valves. Length of rod 0.065–0.09 mm. Posterior ring of buccal capsule 0.045 mm wide. Dorsoventral width of cephalic end at the anterior corners 0.13 mm.

101 Length of esophagus 0.92 mm, width 0.12 mm; esophagus divided into a club-shaped anterior part 0.42 mm long and 0.06 mm wide and a cylindrical glandular posterior part 0.5 mm long and 0.12 mm wide. Nerve ring situated 0.19 mm, excretory pore 0.32 mm from cephalic end.

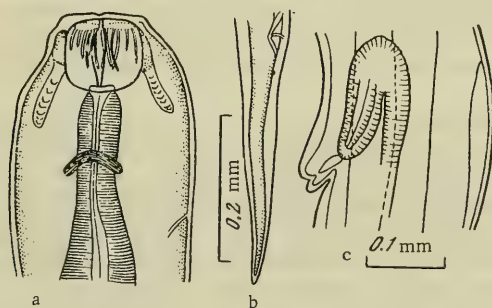


FIGURE 55. *Camallanides* sp. Gupta, 1959:

a — cephalic end of female, lateral; b — caudal end of female, lateral;
c — region of vulva (after Gupta, 1959).

Tail conical, 0.33 mm long. Lips of vulva forming a tubular appendage which is dorsoventrally flattened and projects posteriorly for 0.04 mm. This appendage is situated slightly before middle of body, 4.6 mm from the cephalic end. Vulva situated on the ventral side of the appendage, near its end. The vagina extends anteriorly to the opening of the appendage.

Reference: Gupta, 1959, pp. 778–779.

Genus *Paracamallanus* Yorke and Maplestone, 1926

Synonym: *Camallanus* Railliet and Henry, 1915 (in part)

Diagnosis. Camallaninae, characterized by a markedly widened

connection between buccal capsule and esophagus. This part of the body is not surrounded by a cuticular ring and is almost funnel-shaped. Buccal capsule markedly laterally compressed, especially anteriorly. The slitlike mouth extends far posteriorly on the dorsal and ventral side. The capsule is much wider than long laterally. There are a few longitudinal ribs on the inside of the buccal capsule. The ribs of the right and left side are situated opposite each other and are short, extending only for about half the length of the capsule. Tridents present. Lips of vulva weakly developed.

Type species: *Paracamallanus cyathopharynx* (Baylis, 1923) Yorke and Maplestone, 1926.

102 *Paracamallanus cyathopharynx* (Baylis, 1923) Yorke and Maplestone, 1926 (Figure 56)

Synonym: *Camallanus cyathopharynx* Baylis, 1923

Hosts: *Heterobranchus anguillaris*, *Clarias lazera*.

Localization: intestine and pyloric caeca.

Distribution: Egypt.

Historical review

Paracamallanus cyathopharynx was described by Baylis (1923a) from *Heterobranchus anguillaris* in Egypt. The main character of the species is a large, chitinized "buccal cavity" or "pharynx" behind and in addition to the paired buccal valves. This structure separates the valves from the esophagus. Baylis was not sure that spicules were present and he found only 5 preanal papillae.

In the same host and also in *Clarias lazera*, Campana-Rouget (1961a) found specimens which were identical with the species of Baylis. Campana-Rouget transferred *Camallanus sweeti* Moorthy, 1937 and *Neocamallanus singhi* Ali, 1956 to the genus *Paracamallanus*. She probably did not know Yeh's study (Yeh, 1960b), in which the genus *Zeylanema* Yeh, 1960 was established because of differences in the structure of the buccal capsule in species of *Camallanus*. *Camallanus sweeti* Moorthy, 1937 is a synonym of *Zeylanema sweeti* (Moorthy, 1937) Yeh, 1960, and *Neocamallanus singhi* is a synonym of *Camallanus singhi* (Ali, 1956) Yeh, 1960.

- 103 Description (after Baylis, 1923a). Striation of cuticle with intervals of 0.006 mm. Length of chitinous buccal apparatus, including valves and pharynx 0.1–0.13 mm. Buccal valves with 10–12 longitudinal ribs of different length; tridents absent. The small cervical papillae are situated just behind the nerve ring and the excretory pore slightly before the posterior end of the muscular part of the esophagus.

Male. Length of largest specimen 5.9 mm, maximum width 0.12 mm. Length of esophagus 0.93–1.1 mm, muscular part 0.44–0.56 mm long. Tail 0.05–0.07 mm long. Five pairs of preanal papillae, situated at the sides, widely spaced. Spicules not found; the males were probably not mature.

Campana-Rouget (1961a) gives the following information on the male. Right spicule chitinized, 0.210–0.230 mm long, ending in a small pointed process, without a wing and with a wide sheath. Left spicule more strongly chitinized, very small, 0.025–0.030 mm long, resembling a gubernaculum. The vesicular caudal wings are united before the cloaca and connected

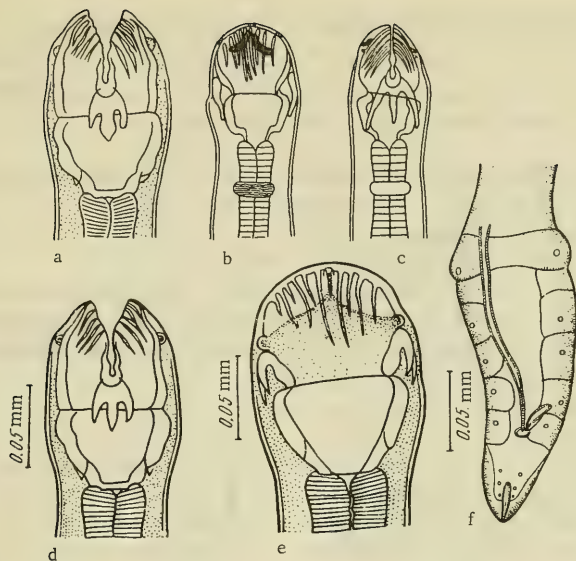


FIGURE 56. *Paracamallanus cyathopharynx* (Baylis, 1923):

a, b, c — cephalic end, different aspects; d — cephalic end of female, dorsal; e — same, lateral; f — posterior end of male (a — after Yorke and Maplestone, 1926; b, c — after Tornquist, 1931; d, e — after Baylis, 1923; f — after Campana-Rouget, 1961).

ventrally. Papillae difficult to distinguish, 5 pairs of preanal and 3 pairs of subventral postanal papillae were found. There may be 2 further pairs of lateral papillae, one in the middle of the tail and the other nearer its end. Except for the first postanal pair, all papillae are very small.

Female. Length of largest specimen 9.2 mm, width 0.18 mm. Length of esophagus 1.28–1.32 mm, muscular part 0.65–0.67 mm long. Tail 0.35–0.40 mm long. Vulva not protruding, situated slightly behind middle of body (4.3 mm from the posterior end in a specimen 9.2 mm long). The vagina extends posteriorly for 0.8 mm. Viviparous.

References: Baylis, 1923a, pp.1–38; Campana-Rouget, 1961a, pp.25–27; Tornquist, 1931, p.234; Yeh, 1960b, pp.117–124; Yorke and Maplestone, 1926, pp.378–379.

Genus *Piscilania* Yeh, 1960

Synonym: *Camallanus* Railliet and Henry, 1915

Diagnosis. Camallaninae. Buccal capsule with inner longitudinal ridges which are short anteriorly and spinelike posteriorly.

Parasites of marine fishes.

Type species: *Piscilania melanocephalus* (Rudolphi, 1819) Yeh, 1960.

Piscilania melanocephalus (Rudolphi, 1819) Yeh, 1960
(Figure 57)

Synonyms: *Cucullanus melanocephalus* Rudolphi, 1819;
Camallanus melanocephalus Rudolphi, 1819

Hosts: *Pelamys* sp., *Auxis* sp., *Scombrus sarda*,
S. rochei, *S. colias*, *Thunnus thynnus*.

Localization: intestine.

104 Distribution: Mediterranean, North Sea.

Description (after Tornquist, 1931). Cuticle transversely striated. Ribs on valves of buccal capsule not extending their whole length, only about half the length of the capsule. Cephalic end slightly narrowing at the connection of the two parts of the esophagus.

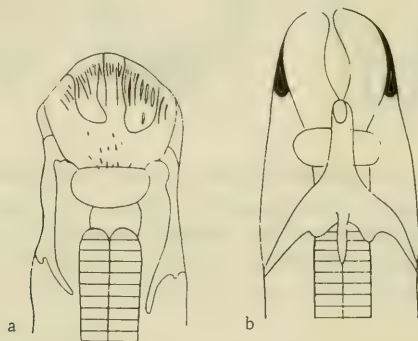


FIGURE 57. *Piscilania melanocephalus* (Rudolphi, 1819) Yeh, 1960:

a, b — cephalic end, different aspects (after Tornquist, 1931).

Male. Length 12.59 mm, width 0.296 mm. Length of buccal capsule 0.109 mm. Chitinized ring at the base of the capsule 0.039 mm long, 0.078 mm wide. Branches of tridents extending from the large cuticular plate, immediately behind the mouth. Lateral branches of tridents markedly longer and thicker than median branch, extending 0.218 mm from the cephalic end. Lateral branches 0.078 mm long, median branch 0.0312 mm. Anterior part of esophagus 1.482 mm long, posterior part 0.936 mm. Tail with rounded end, 0.109 mm long. Spicules indistinct, right spicule 0.687 mm long, left spicule 0.608 mm. Number and arrangement of papillae not determined.

Reference: Tornquist, 1931, p. 341.

Genus *Serpinema* Yeh, 1960

Synonym: *Camallanus* Railliet and Henry, 1915 (in part)

Diagnosis. Camallaninae. Buccal ridges smooth, divided into dorsal and ventral groups.

Parasites of reptiles.

Type species: *Serpinema intermedius* (Hsü and Hoeppli, 1931) Yeh, 1960.

Serpinema intermedius (Hsü and Hoeppli, 1931) Yeh, 1960
(Figure 58)

Synonym: *Camallanus intermedius* Hsü and Hoeppli, 1931

Host: *Geoclemys reevesi*.

Localization: small intestine and rectum.

Distribution: China.

- 105 Description (after Hsü and Hoeppli, 1931). Cuticle finely transversely striated. Buccal valves slightly wider than long, with 10 longitudinal ribs and with subventral and subdorsal papillae. At the anterior part of the valves are formations which are difficult to see, probably amphids. Tridents well developed. Winglike formations around the mouth in apical view, two on each lip. Esophagus divided into a muscular anterior part and a glandular posterior part. Nerve ring situated near base of buccal capsule. Cervical papillae very small.

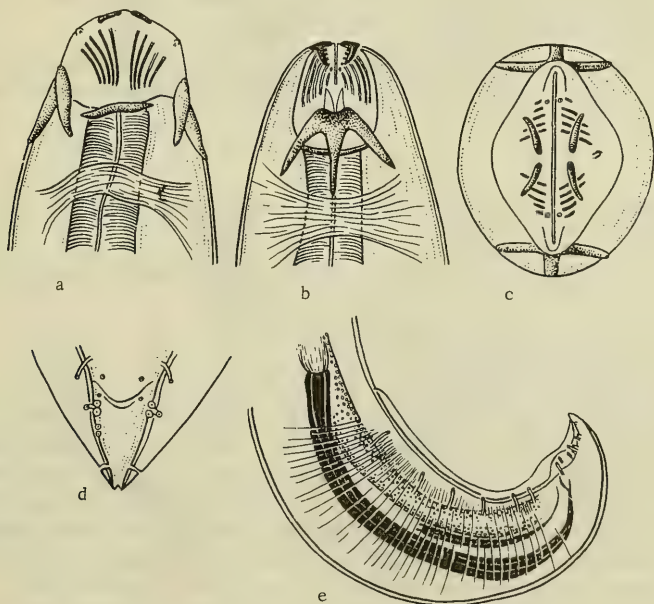


FIGURE 58. *Serpinema intermedius* (Hsü and Hoeppli, 1931):

a — cephalic end, lateral; b — same, ventral; c — same, apical; d — caudal end of male, ventral; e — same, lateral (after Hsü and Hoeppli, 1931).

Male. Length 5.65–7.90 mm, width 0.20–0.23 mm. Dorsoventral width of cephalic end 0.14–0.16 mm, lateral width 0.13–0.15 mm. Dorsoventral

width of cuticular ring 0.035–0.090 mm. Median branch of trident 0.060–0.085 mm long. Nerve ring situated 0.16–0.165 mm, excretory pore 0.26–0.28 mm, cervical papillae 0.31–0.41 mm from cephalic end. Muscular part of esophagus 0.45–0.51 mm long, glandular part 0.49–0.55 mm.

Caudal wings well developed; 7 pairs of riblike preanal papillae, 2 pairs of small adanal papillae, and 5 pairs of postanal papillae, which form two groups on each side: one group of three and the other of two pairs of papillae. 106 Near the end of the tail are two openings of caudal glands. Tail with bifid end, 0.55–0.56 mm long. Right spicule thick, 0.49–0.63 mm long, with bifid end. The two ends of the spicule are of different length, the shorter about $2/3$ as long as the longer. Left spicule thin, 0.20–0.26 mm long, ending in a fine process. The preanal papillae, except the pair at the anus, form the line from which muscles resembling a sucker radiate to both sides.

Female. Length 11.05–12.1 mm, width 0.275–0.345 mm. Dorsoventral width of cephalic end 0.165–0.175 mm, lateral width 0.11–0.13 mm. Dorsoventral width of cuticular ring 0.082–0.14 mm. Median branch of trident 0.10–0.12 mm long. Nerve ring situated 0.17–0.215 mm, excretory pore 0.27–0.315 mm, cervical papillae 0.41–0.535 mm from cephalic end. Muscular part of esophagus 0.52–0.56 mm long, glandular part 0.60–0.69 mm.

Tail trifid, 0.17–0.21 mm long. Vulva situated slightly behind middle of body, 0.525–0.600 mm from end of tail. Lips of vulva indistinct. Vagina long, with strongly muscular walls. Two opposite uteri, posterior branch ending blind, without an ovary. Viviparous.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 26; Hsü and Hoeppli, 1931, pp. 567–588; Yeh, 1960, pp. 107–116.

Serpinema amazonicus (Ribeiro, 1941) Yeh, 1960
(Figure 59)

Synonym: *Camallanus amazonicus* Ribeiro, 1941

Host: *Podocnemis expansa*.

Localization: intestine.

Distribution: Brazil.

Description (after Ribeiro, 1941). Cuticle transversely striated with intervals of 0.008 mm. Cephalic end truncate in both sexes. Tail tapering in the female. Buccal capsule with two valves, two tridents and separated ventrally or dorsally from the body by cuticular grooves. Buccal valves lateral, curved inward. Each valve with 17–20 longitudinal ribs on the inner surface. They have four thickenings on the outer surface, two anterior transverse and two median in the form of a crescent. The tridents, are situated at the connection of the valves. The tridents consist of a main body 0.087 mm long and 0.069 mm wide, in the form of a disk, with three diverging branches of about the same length. The outer margin of the median branch shows distinct serration, and there is a curve along the posterior margin of the cuticular groove at the distal end. A chitinized ring at the connection between valves and esophagus. Cephalic papillae difficult to distinguish, two pairs present, one laterodorsal, the other lateroventral.

Esophagus divided into an anterior club-shaped part and a posterior tubular part, with a fold in the anterior third; at the posterior end of the esophagus are three valves which project into the intestine.

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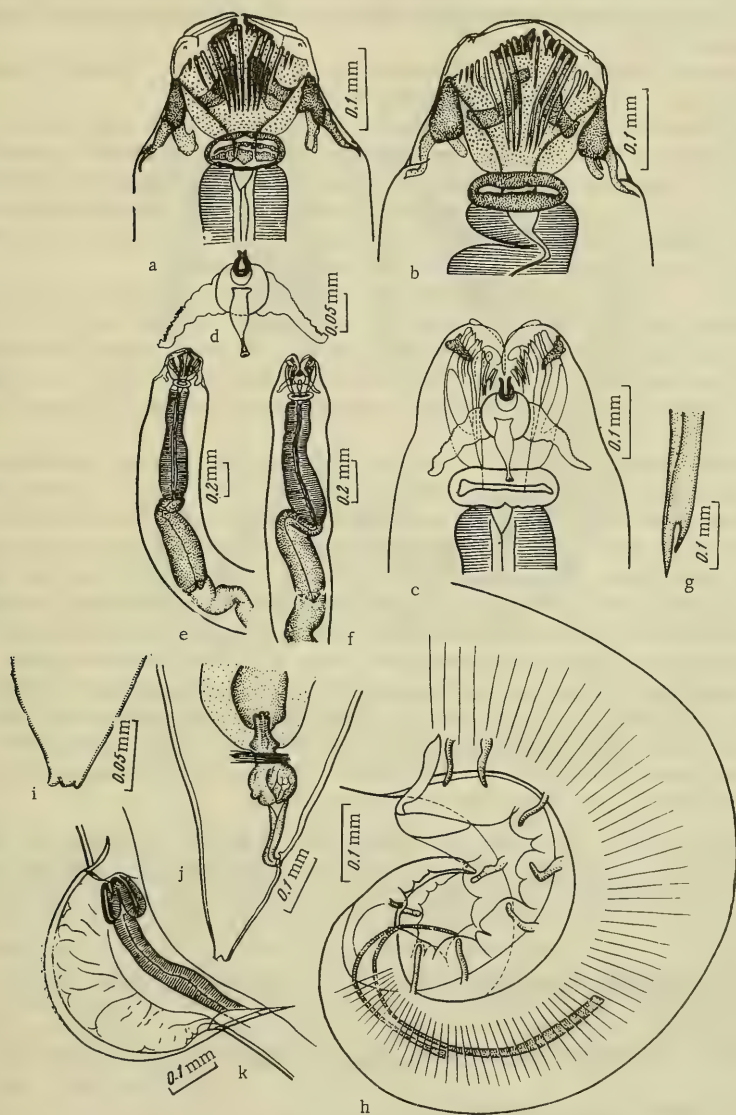


FIGURE 59. *Serpinema amazonicus* (Ribeiro, 1941):

a, b — cephalic end, lateral; c — cephalic end, dorsal; d — trident; e — anterior end, lateral; f — same, dorsal; g — distal end of large spicule; h — caudal end of male, lateral; i — end of tail of female; j — caudal end of female, lateral; k — region of vulva (after Ribeiro, 1941).

108 Cervical papillae and excretory pore not recognizable. Intestine narrower than esophagus.

Male. Length 11.95 mm, width 0.40 mm. Buccal valves 0.17 mm long, 0.18 mm wide. Median branch of trident 0.069 mm long. Chitinized ring 0.043 mm long and 0.104 mm wide. Length of esophagus 1.14 mm, anterior part 0.61 mm long, posterior part 0.53 mm. Nerve ring situated 0.40 mm from cephalic end.

Tail curved ventrally, with transverse musculature. Caudal wings well developed, fused anteriorly, extending to end of tail.

Caudal papillae arranged as follows: 7 pairs preanal, long and pedunculate, one pair pedunculate, postanal, and one pair of postanal sessile papillae near end of tail. Spicules threadlike, of different length. Larger spicule 0.57 mm long, with wider base and bifid end. Smaller spicule more weakly chitinized, about 0.24 mm long. Gubernaculum absent. End of tail conical, not bifid. Anus situated 0.13 mm from posterior end.

Female. Length 15.08–17.92 mm, width 0.53–0.68 mm. Buccal valves 0.204–0.208 mm long and 0.226–0.239 mm wide. Median branch of trident 0.078–0.087 mm long. Chitinized ring 0.056 mm long and 0.139 mm wide. Length of esophagus 1.38–1.40 mm, anterior part 0.73–0.75 mm long, posterior part 0.63–0.65 mm long. Nerve ring situated 0.426 mm from cephalic end.

Uteri didelphic, prodelphic. Vulva with lips protruding to different length in different specimens, situated 8.64–9.17 mm from anterior end. Ovejector divided into a widened, strongly muscular anterior part 0.078–0.096 mm long and 0.096–0.10 mm wide and a narrow posterior part 0.304–0.391 mm long and 0.052 mm wide. If the anterior lip of the vulva protrudes, the vagina is directed obliquely anteriorly; if the posterior lip protrudes, the vagina is directed obliquely posteriorly. Uteri divergent, posterior branch without an ovary, ending in a blind sac about 0.938 mm from the posterior end. Anterior uterus passing into the ovary at about the connection between esophagus and intestine. Uterus filled with larvae, which are comma-shaped, 0.252 mm long and 0.008 mm wide, with conical end. Tail ending in three processes, one dorsal and two lateroventral. Rectum 0.18 mm long. Anus with indistinct lips, situated 0.21 mm from posterior end.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 25; Diaz-Ungria, Gallardo, and Manuel, 1968, pp. 550–570; Ribeiro, 1941, pp. 723–727; Yeh, 1960b, pp. 117–124.

Serpinema kachugae (Baylis and Daubney, 1922) Yeh, 1960
(Figure 60)

Synonym: *Camallanus kachugae* Baylis and Daubney, 1922

Host: *Kachuga smithii*.

Localization: intestine.

Distribution: Japan.

109 Description (after Baylis, 1939). Striation of cuticle with intervals of 0.005 mm. Dorsoventral width of cephalic end at its anterior corners 0.13–0.15 mm in males and 0.17 mm in females. Buccal valves slightly wider than long, 0.11–0.13 mm long without the posterior ring and 0.14–0.16 mm wide. Valves with 8 or 10 longitudinal ribs, ten ribs present only in large

specimens. Width of posterior ring of buccal apparatus 0.1 mm. Median branch of tridents 0.08–0.1 mm long. Length of esophagus, measured from the cephalic end, 1.18–1.55 mm, anterior part, 0.54–0.66 mm. Nerve ring situated 0.20–0.23 mm and the small seta-shaped cervical papillae 0.50–0.55 mm from the anterior end. Excretory pore situated at the level of the papillae. Intestine markedly narrower than esophagus.

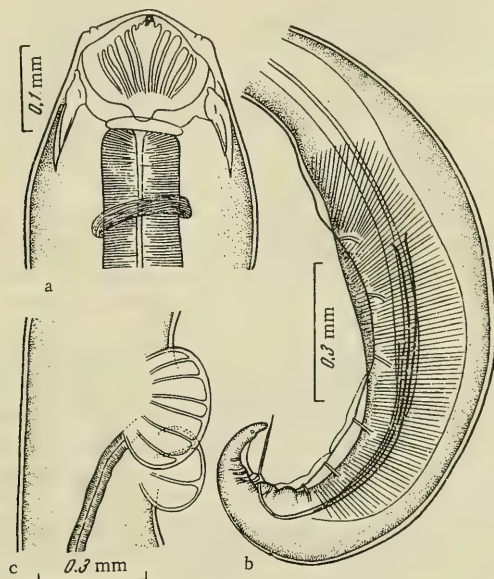


FIGURE 60. *Serpinema kachugae* (Baylis and Daubney, 1922):

a — anterior end of female, lateral; b — caudal end of male, lateral;
c — region of vulva, lateral (after Baylis and Daubney, 1922).

Male. Length 10.9–14.5 mm, width 0.3–0.37 mm. Body slightly thicker in the region of the caudal wings than further anteriorly. The ventral region between the wings can apparently be depressed by the caudal muscles, forming a suckerlike organ. Seven pairs of pedunculate preanal papillae, 2 pairs of adanal papillae, and 6 pairs of postanal papillae. The first two pairs of postanal papillae are separated; the third, fourth, and fifth pairs form a group. All papillae are lateral, but the sixth pair is situated more ventrally, slightly behind the cloaca. Right spicule relatively thick, about 0.97 mm long. Its distal end is apparently simple and finely pointed. Left spicule very thin, 0.43 mm long.

Female. Length 20.8–22 mm, width 0.45–0.5 mm. Tail finger-shaped, blunt and with slightly bifid end. Tail about 0.3 mm long; a pair of papillae 0.17 mm from the end, situated in small depressions of the cuticle. Vulva situated before middle of body, 9.1–10.4 mm from anterior end. It has strongly protruding lips, anterior lip wider than posterior lip and overlapping it. Each lip consists of a cuticular swelling with granular content and is divided inside into several parts by cuticular septa. Vagina narrow, extending posteriorly for about 2 mm, gradually widening, and passing into the short common duct of the uterus, which extends posteriorly.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.26; Baylis, 1939, pp.207-210; Baylis and Daubney, 1922, pp.322-325; Yeh, 1960b, pp.107-116.

Serpinema magathi (Sprehn, 1932) Yeh, 1960
(Figure 61)

Synonyms: *Camallanus magathi* Sprehn, 1932; *C. parvus* Caballero, 1939

Hosts: *Clinosternum scorpioides*, *C. integrum*, *C. hiraipes*.

Localization: intestine.

Distribution: Bolivia, Mexico.

Description (after Sprehn, 1932). Cuticle finely transversely striated with intervals of 0.002 mm. Median rib of buccal capsule with four ends on each side. Cervical papillae situated immediately behind the nerve ring, 0.65 mm from the cephalic end. Excretory pore situated 0.767 mm from the cephalic end.

Male. Length 7.65 mm, width 0.38 mm. Length of valves 0.12 mm, width 0.138 mm. Length of muscular part of esophagus 0.39 mm, width 0.13 mm, length of glandular part 0.585 mm, width 0.156 mm. Three valves about 0.065 mm long at the connection between esophagus and intestine. Tail with blunt end, 0.113 mm long. Spicule 0.65 mm long, width at base of terminal process 0.010 mm.

Female. Length 8.8-10.5 mm, width 0.5 mm. Length of valves 0.14 mm, width 0.165 mm. Muscular part of esophagus 0.487 mm long, 0.156 mm wide, glandular part 0.78 mm long, 0.218 mm wide.

Vulva situated 5.1-5.3 mm from cephalic end, with two lips. Vagina extending posteriorly. Tail with blunt end. Tail 0.212 mm long, indistinctly bifurcate. Size of eggs 0.03×0.027 mm.

Description (after Caballero, 1939a). Cuticle transversely striated. Maximum width at anterior part of the esophagus. Buccal capsule with two valves, with 11 straight ribs which do not extend to the chitinized ring and form an angle. A short rib is also present in the middle of the buccal capsule, at the level of the median papilla.

Male. Length 3.783 mm, width 0.292 mm. Length of buccal capsule 0.107 mm, width 0.115 mm. Width of chitinized ring at base of buccal capsule 0.086 mm. Length of lateral branches of trident 0.086 mm, of median 111 branch 0.061 mm; branches flat and wide. Anterior part of esophagus 0.328 mm long, 0.066 mm wide anteriorly and 0.11 mm posteriorly. Nerve ring situated 0.172 mm, cervical papillae 0.273 mm from cephalic end.

Anus situated 0.092 mm from end of tail. Tail with two wings. Seven pairs of preanal lateral papillae with a long stalk and 4 pairs of postanal papillae, three of them behind the cloaca and a smaller one at the end. Caudal wings 0.273 mm long. Larger spicule 0.585 mm long and 0.016 mm wide, with a hairlike process 0.041 mm long at the distal end.

Female. Length 7.15-7.90 mm, width 0.37-0.39 mm. Length of buccal capsule 0.115-0.135 mm, width 0.131 mm. Chitinized ring 0.094-0.098 mm wide. Lateral branches of trident 0.090 mm long, median branch 0.074 mm. Length of anterior part of esophagus 0.370 mm, width 0.082 mm at its anterior end

and 0.131–0.152 mm at its posterior end. Glandular part of esophagus 0.585 mm long and 0.131–0.135 mm wide. Nerve ring situated 0.173–0.213 mm from cephalic end. Cervical papillae and excretory pore not found.

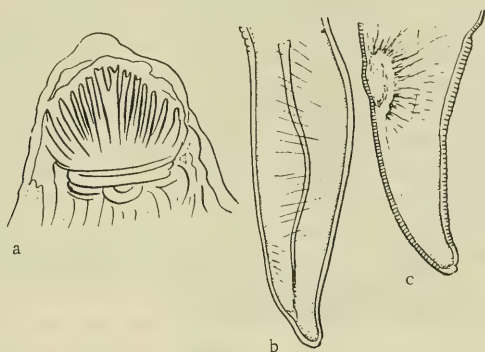


FIGURE 61. *Serpinema magathi* (Sprehn, 1932):

a — cephalic end, lateral; b — caudal end of male, lateral;
c — caudal end of female, lateral (after Sprehn, 1932).

Vulva with strongly developed lips, situated in posterior half of body, 3.35–3.80 mm from end of tail. The two uteri are opposite. Anus situated 0.253 mm from end of tail which is finger-shaped and ends in three papillae.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 27; Caballero, 1939a, pp. 448–450; Sprehn, 1932, pp. 283–294; Yeh, 1960b, pp. 107–116.

Serpinema microcephalus (Dujardin, 1845) Yeh, 1960
(Figures 62–64)

Synonyms: *Camallanus microcephalus* (Dujardin, 1845); *C. trispinosus* (Leidy, 1861); *C. confusus* Railliet and Henry, 1915; *C. chelydrae* MacCallum, 1918; *C. cyathocephalus* MacCallum, 1918; *C. elegans* MacCallum, 1918; *C. floridianae* MacCallum, 1918; *C. scabrae* MacCallum, 1918; *C. testudinis* MacCallum, 1918; *C. americanus* Magath, 1919; *C. seurati* Magath, 1919; *Cucullanus testudinis* Rudolphi, 1819; *C. microcephalus* Dujardin, 1845; *C. dumerillii* Perrier, 1871

112 Hosts: *Emys lutaria*, *E. orbicularis*, *Clemmys caspica*, *Cl. leprosa*; *Chrysemys picta*; *Ch. troosti*; *Ch. elegans*; *Chelydra serpentina*; *Chrysemys scabrae*?; *Chr. floridana*; *Chr. marginata*; *Chr. scripta*; *Malacoclemmys lesueuri*; *Aromochelys odoratus*; *Trionyx spiniferus*; *Tr. muticus*; *Dermatemys mawii*.

Localization: intestine.

Distribution: Europe, Algeria, North America.

Historical review

Dujardin (1845) described an nematode from *Emys orbicularis* as *Cucullanus microcephalus*. Perrier (1871) gave a description of *Cucullanus dumerillii* after a specimen from a tortoise in the Zoological Garden in Paris. Linstow described in 1897 *Cucullanus dumerillii* Perrier, 1871 from *Emys* sp.? in the Zoological Garden in Hamburg. Railliet and Henry (1915) thought that the specimen described by Linstow is different from that of Perrier, and they renamed it *Cucullanus confusus*. Seurat (1915) described a species of the genus *Camallanus* from *Clemmys leprosa* as *Cucullanus microcephalus* Duj. Magath (1919a) stated that Dujardin's description of a specimen from *Clemmys* was inaccurate, and named it *C. seurati*, although he could not determine the species according to Dujardin's description. This inconsistency was pointed out by Baylis and Daubney in 1922.

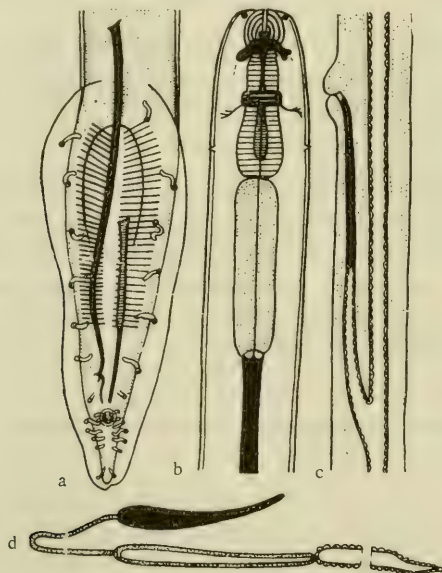


FIGURE 62. *Serpinema microcephalus* (Dujardin, 1845):

a — posterior end of male, ventral; b — anterior end, ventral; c — region of vulva, lateral; d — terminal part of uterus, oviduct, and ovary (diagrammatic) (after Seurat, 1915).

Tornquist (1931) described *Camallanus microcephalus* from material of the Zoological Museum in Berlin from *Emys* sp. and from *Clemmys leprosa* (in Tornquist's view, this is not *leprosa*, since there were two labels on the jar, on one of them a question mark after the word *leprosa*). Tornquist noted that the specimens from *Emys* and from *Clemmys* were identical. Thus, *Camallanus confusus* Railliet and Henry, 1915 and *Camallanus seurati* Magath, 1919 are the same species.

Linstow determined the specimens in the Berlin museum from *Emys* sp. as *Cucullanus dumerillii* Perrier. There is no information as to whether these specimens were used for the description of this species in 1897, although Tornquist thought that this is possible. The host is the same in the description and on the label, but its locality is not mentioned.

Tornquist did not find it justified to separate the species described by Linstow in 1897 from that described by Perrier in 1871. He also thought that it was not justified for Magath to consider the forms of *Camallanus* from *Emys orbicularis* and from *Clemmys leprosa* as different species merely according to Dujardin's description (1845).

Tornquist also thought that all North American species of the genus *Camallanus* from *Chelonia* are synonyms of *C. microcephalus*, and considered only *C. scabrae* MacCallum, 1918 as a valid species. Caballero (1943) gave a detailed description and drawings of this species, which we give below under *Serpinema microcephalus*, since we agree with Chitwood (1933b), who considered *C. scabrae* and the other North American species of the genus as synonyms of *C. microcephalus*.

Yeh (1960b) divided the genus *Camallanus* into several genera and transferred the species *Camallanus microcephalus* to the genus *Serpinema*.

Description (after Tornquist, 1931). Cuticle transversely striated. Six oral papillae. Each valve of buccal capsule with 10 ribs which form two groups, an upper and a lower group; the ribs are curved and extend obliquely posteriorly. Short ribs are absent behind the mouth and behind the chitinated ring. A strong thickening extends in the midline, almost through the whole buccal capsule. Branches of tridents of equal length, the outer branches wider than the median branch, which is more pointed.

Behind the buccal capsule begins the anterior part of the esophagus, which is here half as wide as in its posterior part.

The cephalic end becomes narrower at the anterior part of the posterior part of the esophagus; this narrowing is small in the male but more distinct in the female.

Male. Length 6.93–10.84 mm, width 0.265 mm. Thickness of cuticle at the nerve ring and at the cloaca 0.0025 mm, in the middle of the body 0.0028 mm. Depth of buccal capsule 0.109 mm. Anterior end of esophagus situated 0.468 mm from the cephalic end. Length of posterior part of esophagus 0.780 mm. Opening of dorsal esophageal gland situated 0.040 mm behind the buccal capsule, openings of subventral glands situated 0.035 mm from beginning of posterior part of esophagus. Nerve ring situated 0.203 mm from cephalic end. Excretory pore situated 0.190 mm behind the nerve ring; length of efferent duct 0.125 mm. Excretory organ U-shaped. Cervical papilla on the right side situated 0.135 mm behind the nerve ring, left papilla 0.160 mm behind it. The papillae are slightly raised above the surface. The boundaries between the cells are clearly visible in the anterior part of the intestine, but the nuclei are not recognizable. Rectum 0.130 mm long, cloaca 0.085 mm.

The testis ends 0.750 mm behind the connection of the esophagus with the intestine. Anterior part of testis coiled, the anterior coil situated 0.460 mm from the connection between esophagus and intestine; posterior part of testis straight. The narrow transitional part leading to the vas deferens is about 0.050 mm long. Vas deferens 1.180 mm long; it becomes narrower proximally, and the duct becomes markedly wide 0.750 mm from its beginning (seminal vesicle). Transitional part leading to ejaculatory duct 0.060 mm long. Length of ejaculatory duct 1.270 mm.

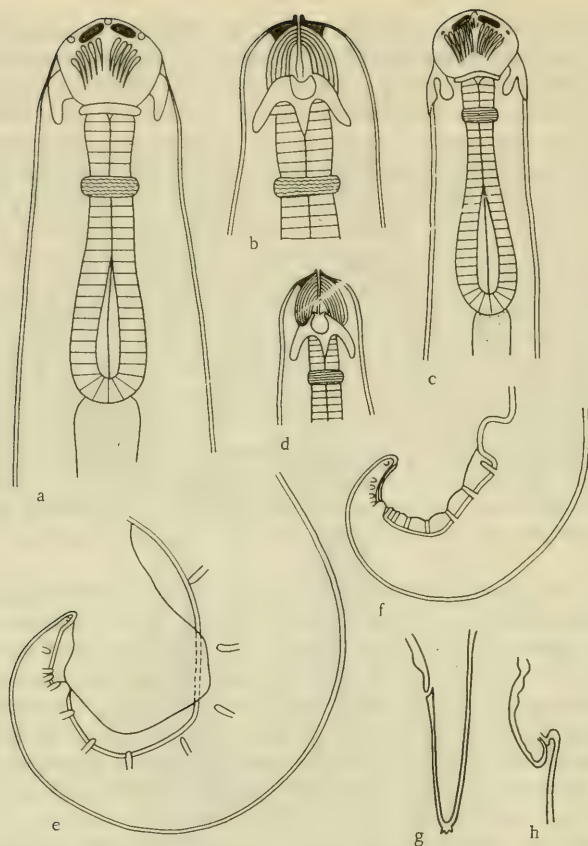


FIGURE 63. *Serpinema microcephalus* (Dujardin, 1845):

a—d— anterior end, different aspects; e, f— caudal end of male, lateral; g— caudal end of female, lateral; h— region of vulva, lateral (after Tornquist, 1931).

Length of tail 0.062 mm. Seven pairs of precloacal and 5 pairs of postcloacal papillae. Precloacal papillae situated subventrally. The three anterior pairs of postcloacal papillae are also subventral, situated close together, and larger than the other two pairs. Distance between second and third pair of postcloacal papillae (counting from end of tail) smaller than that between the second and first pairs, which are situated near the end of the tail. The postcloacal papillae at the end of the tail are lateral. Spicules of different length, right spicule 0.800 mm long, 115 left spicule 0.380 mm. Larger spicule with a small wing on the left side. Both spicules with rounded cross section.

Female. Length 11.684–12.730 mm, width 0.390 mm. Thickness of cuticle at the nerve ring 0.0028 mm, at the vulva 0.0042 mm, and at the anus 0.0025 mm. Depth of buccal capsule 0.125 mm. Anterior end of esophagus situated 0.562 mm from cephalic end. Posterior part of esophagus 0.687 mm long.

Vulva situated 5.647 mm from the cephalic end, with strong lips, the anterior lip markedly thicker than the posterior and directed obliquely posteriorly. The duct from the vulva is curved broadly anteriorly (about 0.030 mm). Only this U-shaped part of the duct is covered with cuticle.

The posterior branch of the uterus is curved anteriorly for 0.230 mm. This curve is situated 0.250 mm from the rectum. The anterior branch extends to the point where the two branches unite and then turns posteriorly. Oviduct 1.430 mm long, without loops. Seminal vesicle beginning 0.430 mm from the uterus; it is 0.500 mm long. Ovary extending posteriorly for 1.270 mm and then turning anteriorly. The part extending anteriorly is about 0.750 mm long, and there is another part extending posteriorly for about 0.400 mm. Length of ovary about 2.420 mm.

Posterior part of body tapering to end of tail. Tail 0.172 mm long, pointed.

Description (after Caballero, 1943). Coloration reddish. Females much larger than males. Cuticle transparent, with transverse striation which is more distinct than the longitudinal striation, with intervals of 0.012–0.024 mm. Anterior end rounded, wider than the posterior end, with 3 pairs of papillae: a mediolateral, a ventrolateral, and a dorsolateral pair. Valves of buccal capsule lateral, convex outside and concave inside, yellowish red, with chitinized walls, each with 15 chitinized ribs which are wide anteriorly and pointed where they converge near the esophagus. Median dorsal rib short, the lateral ribs longer, extending to the cuticular ring at the base of the valves. Ribs attached anteriorly to two chitinized lateral plates, which curve at a right or acute angle to the dorsal and ventral surface of the capsule. Posterior part of buccal capsule attached to the cuticular ring. At the level of the ring are tridents dorsally and ventrally, their branches with sinuous or serrate margin; their ends often widen in the form of a hook, and their middle bears a disk which has a notch anteriorly. Esophagus divided into a club-shaped muscular anterior part which begins at the ring; the posterior part is cylindrical and glandular. Valves are present at the connection of the muscular and glandular esophagus and of the glandular part with the intestine. Intestine cylindrical with thick walls.

Male. Length 9–9.217 mm, width 0.236–0.273 mm. Length of buccal valves 0.112–0.116 mm, width 0.136–0.140 mm; thickness of valves at the base 0.015–0.020 mm. Length of ribs 0.065 mm, width 0.004–0.005 mm, length of smaller ribs 0.008 mm. Length of cuticular ring 0.013–0.023 mm, width 0.086 mm. Length of tridents 0.100 mm, space between lateral branches 0.144 mm. Length of disk 0.044 mm, width 0.044–0.056 mm. Median branch of trident 0.078 mm long, 0.010 mm wide; right branch 0.096 mm long, 0.020 mm wide, left branch 0.092 mm long, 0.024 mm wide. Muscular part of esophagus 0.436 mm long, 0.127–0.136 mm wide; glandular part 0.582–0.618 mm long, 0.100–0.145 mm wide. Intestine 0.084–0.088 mm wide. Anus situated 0.152–0.196 mm from end of tail.

Nerve ring situated 0.160–0.184 mm, excretory pore 0.512 mm, cervical papillae 0.352–0.392 mm from the cephalic end.

Tail finger-shaped, with two small lateral papillae at the end.

Caudal wings finely transversely striated; the lateral muscles in this region converge radially to the opening of the intestine and the spicules. The caudal wings are supported by 10 pairs of pedunculate lateral papillae: 7 pairs preanal and 3 pairs postanal; the two pairs near the cloaca are situated close together. Cloaca with 2 pairs of sessile ventral papillae.

Spicules of different length, narrow and weakly chitinized, ending in a pointed process. Larger spicule 0.772–0.880 mm long 0.016–0.018 mm wide at the manubrium; smaller spicule 0.360–0.368 mm long, 0.008 mm wide at the manubrium. Gubernaculum absent.

(116)

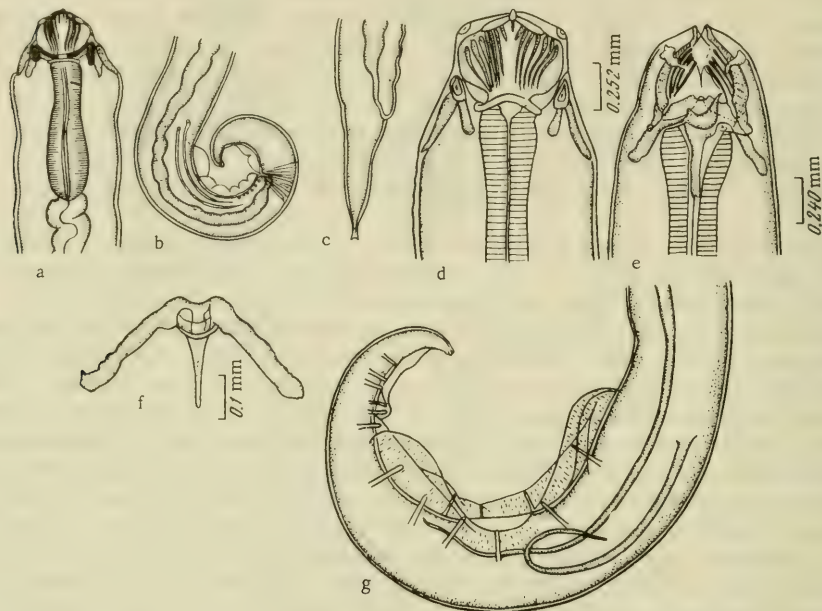


FIGURE 64. *Serpinema microcephalus* (Dujardin, 1845):

a – anterior end, lateral; b – caudal end of male, lateral; c – caudal end of female, lateral; d, e – cephalic end in different positions; f – trident; g – caudal end of male, lateral (a – c – after MacCallum, 1918; d – g – after Caballero, 1943).

Female. Length 13.853–14.598 mm, width 0.345–0.400 mm. Length of buccal capsule 0.120–0.132 mm, width 0.168–0.176 mm, thickness of valves 0.024 mm. Large ribs 0.091–0.099 mm long, 0.005–0.008 mm wide; small ribs 0.015–0.023 mm long. Cuticular ring at base of buccal capsule 0.021–0.026 mm long, 0.112–0.114 mm wide. Tridents 0.095–0.104 mm long, space between lateral branches 0.164–0.176 mm. Median branch of trident 0.056–0.060 mm long, 0.016–0.032 mm wide; right branch 0.096–0.104 mm long, 0.020–0.028 mm wide, left branch 0.104–0.108 mm long, 0.028 mm wide. Middle part of trident 0.044 mm long, 0.056 mm wide.

Muscular anterior part of esophagus 0.436–0.491 mm long, 0.136–0.145 mm wide, glandular part 0.563–0.673 mm long, 0.100–0.116 mm wide. Intestine straight, with 4–5 large rectal cells, which are 0.100–0.160 mm long. Anus situated 0.260–0.291 mm from end of tail.

Nerve ring situated 0.252–0.296 mm, cervical papillae 0.404 mm from cephalic end.

Tail tapering and ending in a process with 3 tubercles. Genitalia amphidelphic, occupying greater part of posterior half of body. Vulva situated

behind middle of body, 7.199–7.544 mm from end of tail. Lips of vulva large, protruding above the surface, 0.309–0.318 mm long and 0.109–0.145 mm wide. Vagina large, cylindrical, muscular, extending anteriorly for 0.460–0.500 mm, 0.044–0.052 mm wide. Two uterine branches. Viviparous. Length of larvae in uterus 0.301 mm, width 0.012 mm.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 27; Baylis and Daubney, 1922, pp. 263–347; Caballero, 1943, pp. 195–200; Chitwood, 1933b, p. 242; Dujardin, 1845, p. 654; Linstow, 1897, pp. 608–632; MacCallum, 1918, pp. 123–124; Magath, 1919a, pp. 49–170; Perrier, 1871, pp. 337–339; Railliet and Henry, 1915, pp. 446–452; Seurat, 1915, pp. 423–426; Tornquist, 1931, pp. 1–441; Yeh, 1960, pp. 107–116.

Serpinema octorugatus (Baylis, 1933) Yeh, 1960 (Figure 65)

Synonym: *Camallanus octorugatus* Baylis, 1933

Host: *Heosemys grandis*.

Localization: stomach, small intestine.

Distribution: Malaysia.

Description (after Baylis, 1933). Cuticle transversely striated with intervals of 0.005–0.006 mm. Valves of buccal capsule, including posterior ring, about as long as wide. Anterior margin of valves with two inner chitinous thickenings. Eight longitudinal ribs on the inner surface of each valve. Tridents with three branches of almost equal length. Median branch narrow and thin laterally; its end is not completely chitinized. Lateral branches thick, wider at the end. Anterior margin of base of trident concave and serrated. Nerve ring situated 0.25–0.40 mm, excretory pore 0.4 mm, cervical papillae indistinct, situated 0.44 mm from the cephalic end.

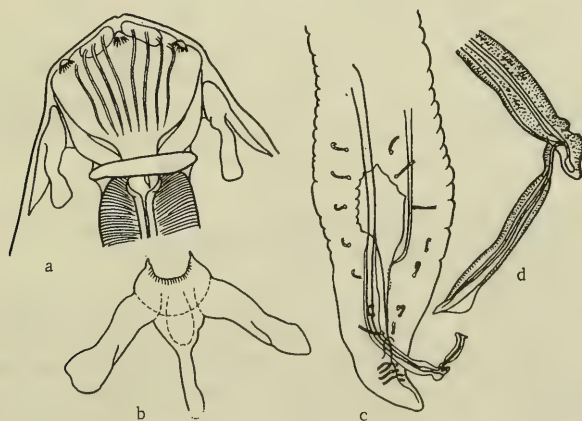


FIGURE 65. *Serpinema octorugatus* (Baylis, 1933):

a – cephalic end of female, lateral; b – trident, dorsoventral; c – caudal end of male, ventral; d – distal end of right spicule, lateral (after Baylis, 1933).

Male. Length 8.6–11.63 mm, maximum width 0.38–0.43 mm. Valves of buccal capsule 0.14–0.15 mm wide. Length of esophagus 1.28–1.3 mm, of muscular anterior part 0.44–0.45 mm, of glandular posterior part 0.68–0.7 mm. Maximum width of esophagus 0.14–0.16 mm. Tail of the form typical for the genus. Wings fleshy and muscular, extending to the ventral surface anteriorly, curved inward ventrally, forming a deep longitudinal groove, at the posterior end of which the cloaca is situated. Tail about 0.13–0.14 mm long. There are usually 7 pairs of pedunculate preanal papillae, 4 pairs of postanal papillae situated close together, and one pair of small, sessile lateral papillae at the end of the tail. Spicules of markedly different length and form. Left spicule weakly chitinized, slender, about 0.5 mm long. Right spicule thicker and strongly chitinized, 0.75–0.76 mm long without the lateral process. It is tubular, with membranous wings at the distal end. A process about 0.14 mm long laterally at its end, bent almost at a right angle to the longitudinal axis. The process is narrow; it becomes thicker distally and has membranous wings.

Female. Length 15.6–19 mm, maximum width 0.55–0.62 mm. Valves of buccal capsule 0.17–0.18 mm wide. Length of esophagus 1.57 mm, of muscular anterior part 0.51–0.6 mm, of glandular posterior part 0.87–0.88 mm. Maximum width of esophagus 0.19–0.2 mm.

Tail 0.24–0.34 mm long, with a pair of indistinct papillae 0.14–0.19 mm from the end. Vulva situated 6.8–7.8 mm from the anterior end, with protruding anterior lip.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 26; Baylis, 1933, pp. 628–632; Yeh, 1960b, pp. 107–116.

Serpinema trispinosa (Leidy, 1852) Yeh, 1960
(Figure 66)

Synonyms: *Cucullanus trispinosus* Leidy, 1852; *Camallanus trispinosus* (Leidy, 1852) Railliet and Henry, 1915; *C. chelydrae* MacCallum, 1918; *C. cyathcephalus* MacCallum, 1918; *C. elegans* MacCallum, 1918; *C. floridianae* MacCallum, 1918; *C. scabrae* MacCallum, 1918; *C. troosti* MacCallum, 1918; *C. americanus* Magath, 1919; *C. microcephalus* (in part) sensu Chitwood, 1932; *C. microcephalus* sensu Rausch, 1947

Host: *Pseudemys decussata*.

Localization: stomach and small intestine.

Distribution: Cuba.

Description (after Baruš and Moravec, 1967). Medium-sized forms with transversely striated cuticle. Anterior end slightly flattened, narrowing toward the buccal capsule. Buccal capsule large, strongly pseudochitinized, consisting of two lateral valves on which there are two lateral groups of 5 ribs extending from the apex to the base of the inner surface. Between these two lateral groups are 4–5 short ribs near the anterior margin of the capsule. Each valve with two transversely striated plates. A strongly pseudochitinized ring at the base of the buccal capsule, which is slightly narrower than the valve. Tridents almost reaching the chitinized ring. Four subapical oral papillae, two dorsolateral and two ventrolateral. A pair of small

lateral cervical papillae 0.002–0.003 mm long. Esophagus consisting of a relatively short, bottle-shaped muscular part which is wider posteriorly and a cylindrical glandular part of about the same length. Muscular part of esophagus lined with cuticle. Nerve ring surrounding muscular part of esophagus near the buccal capsule. Intestine straight, reddish brown. Small unicellular rectal glands around the rectum.

Male. Length 6.93–7.45 mm, maximum width 0.27–0.28 mm. Length of buccal capsule 0.129–0.135 mm, width 0.150–0.171 mm. Tridents 0.075–0.081 mm long. Length of muscular part of esophagus 0.44–0.46 mm, width of its widened part 0.15 mm. Glandular part of esophagus 0.50–0.54 mm long. The small cervical papillae are situated 0.36 mm from the anterior end. Nerve ring surrounding muscular part of esophagus at its anterior end, 0.20–0.23 mm from the cephalic end.

Tail curved ventrally, with subventral caudal wings; 12 pairs of pedunculate caudal papillae, 7 pairs preanal and 5 pairs postanal. The first, second, third, and fourth pairs of postanal papillae are situated close together. Spicules of different length. Longer spicule slightly widening at the proximal end, 0.788–0.816 mm long, smaller spicule 0.360–0.385 mm. Tail 0.163–0.174 mm long.

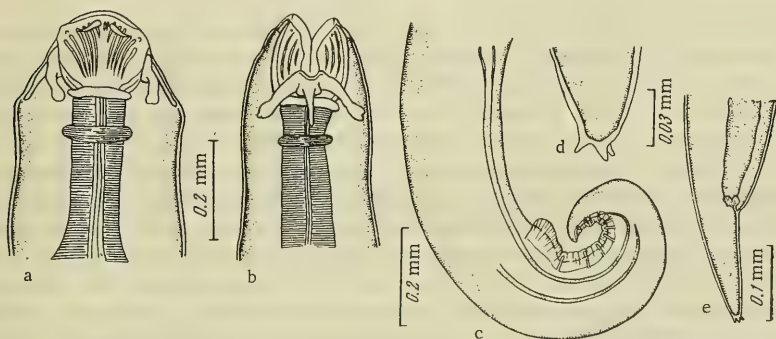


FIGURE 66. *Serpinema trispinosa* (Leidy, 1852):

a – cephalic end, lateral; b – same, ventral; c – caudal end of male, lateral; d – end of tail of female; e – caudal end of female, lateral (after Baruš and Moravec, 1967).

Female. Length 10.60–13.00 mm, maximum width 0.27–0.28 mm. Buccal capsule reddish brown, 0.159 mm long, 0.180–0.195 mm wide. Tridents 0.075–0.111 mm long. Muscular part of esophagus 0.48–0.55 mm long, 0.149–0.163 mm wide. Glandular part of esophagus about as long as the muscular part, 0.43–0.61 mm. The small cervical papillae are situated 0.38 mm, nerve ring situated 0.24–0.25 mm from the cephalic end. Tail conical, distinctly thinner than the body, 0.16–0.27 mm long. It ends in three cuticular processes. Vulva situated 5.16–5.65 mm from the posterior end, its anterior lip protruding, posterior lip small. Vagina relatively short, directed anteriorly. Larvae present in the uterus.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 29; Baruš and Moravec, 1967, pp. 318–320; Yeh, 1960b, pp. 117–124.

Genus *Zeylanema* Yeh, 1960

Synonym: *Camallanus* Railliet and Henry, 1915 (in part)

Diagnosis. Camallaninae. Buccal capsule with two valves with inner longitudinal denticulate ribs, ending in a chitinized ring before the connection with the esophagus. Tridents present or absent.

Male with small caudal wings and two simple spicules of different length.

Parasites of fish.

Type species: *Zeylanema anabantis* (Pearse, 1933) Yeh, 1960.

Zeylanema anabantis (Pearse, 1933) Yeh, 1960 (Figures 67, 68)

121 Synonyms: *Camallanus anabantis* Pearse, 1933 (in part); *C. unispiculus* Khera, 1954

Hosts: *Anabas testudineus*, *Puntius filamentosus*, *Rasbora daniconius*.

Localization: intestine.

Distribution: Thailand, Ceylon, India.

Historical review

Pearse (1933) described this species from *Anabas* in Bangkok. Chakravarty (1939) gave a redescription and a drawing of it from the typical host from India. Kulasiri and Fernando (1956) found it in Ceylon. There are inconsistencies in the original description and drawings of Pearse, as noted by Yeh (1960b). Pearse stated that the males have tridents and the females, which were much smaller, had none. Yeh concluded that Pearse had apparently examined two different species, one with, the other without tridents. The presence of two species of the same family in the same host is a mixed infection, which is quite common. Yeh examined the material of Pearse which consisted of a single female with 10 longitudinal buccal ribs and a pair of tridents; this corresponds to the description of the female by Pearse. The buccal valves, however, corresponded to Pearse's description of the male, and there is no doubt that the female and male do not belong to the same species.

On the basis of the description and drawing of male and female from the collection of Pearse, and also according to the data of the two above publications, Yeh retained the species described by Pearse, and also gave a description of his own material given below. Yeh renamed the other species described by Pearse *Zeylanema pearsei* Yeh, 1960 (*Camallanus anabantis* Pearse, 1933, in part). *Camallanus unispiculus* Khera, 1954 is considered a synonym of *Zeylanema anabantis*. Below we give the description after Pearse, Chakravarty, Yeh, and Khera.

Description (after Pearse, 1933). Cuticle transversely striated. Buccal capsule with two valves with 7–10 ribs.

Male. Length 6.7 mm, width 0.1 mm. Tridents situated above and below the buccal valves. Chitinized buccal capsule 0.09 mm long. Muscular part of esophagus 0.33 mm long, glandular part 0.54 mm. Nerve ring situated 0.07–0.09 mm behind the buccal capsule. Tail 0.063 mm long, conical, curved ventrally, pointed, with two small spines at the end. Four pairs of preanal papillae, 5 pairs of postanal papillae, and 3 pairs of discoid processes

at the end of the tail. Right spicule 0.59 mm long, left spicule 0.14 mm. A depression on the dorsal surface before the anus.

122 Description (after Chakravarty, 1939). Threadlike, transversely striated forms. Ventral pairs of cephalic papillae present. Buccal capsule with two chitinized valves, with 9 pairs of moniliform longitudinal ribs which are shorter on the dorsal and ventral side. Tridents present in both sexes. A chitinized ring at the beginning of the esophagus. Esophagus divided into a muscular and a glandular part.

Male. Length 6.15 mm, width 0.15 mm. Length of muscular part of esophagus 0.4 mm, of glandular part 0.55 mm. Chitinized buccal capsule 0.1 mm long. Nerve ring situated 0.2 mm from the cephalic end. Tail 0.12 mm long, curved ventrally, ending in a spine.

Spicules of different length, right spicule longer. Short precloacal wings present. Papillae: 5 pairs preanal, 5 pairs postanal, one pair adanal, and 3 pairs at end of tail.

Female. Length 21.5 mm, width 0.45 mm. Length of muscular part of esophagus 0.45 mm, of glandular part 0.96 mm. Chitinized buccal capsule 0.15 mm long. Nerve ring situated 0.25 mm from cephalic end. Tail 0.25 mm long, bifid. Viviparous.

Description (after Yeh, 1960b). Buccal valves with 9 longitudinal rows of teeth in both sexes. Five median rows always present on the entire buccal capsule; two outer lateral rows are often shorter. The second outer row is usually short. Tridents distinct.

Male. Length 2.9–4 mm, width 0.10–0.13 mm. Length of buccal cavity 0.07 mm, width 0.08 mm. Muscular anterior part of esophagus 0.29–0.31 mm long, posterior part 0.38–0.46 mm.

Tail 0.09 mm long, with two small finger-shaped processes at the end. Six pairs of precloacal papillae, one pair situated slightly before the cloaca, and 5 pairs of postcloacal papillae, the first pair situated immediately behind the cloaca. A pair of phasmids present. Spicules weakly sclerotized and of different length. Left spicule 0.11 mm long, right spicule 0.58–0.65 mm long.

Female. Length 7.2–15.4 mm, width 0.18–0.31 mm. Buccal cavity 0.10–0.11 mm long and 0.13–0.17 mm wide (dorsoventrally). Muscular anterior part of esophagus 0.36–0.40 mm long, posterior part 0.65–0.78 mm. Nerve ring situated 0.23–0.34 mm from the cephalic end. Tail conical, 0.15 mm long, with three small finger-shaped processes at the end.

Vulva situated slightly before middle of body, dividing the body at the ratio of 1:1.8–1.3.

Description (after Khera, 1954). Nematodes of medium size. Cuticle thin, with weak transverse striation. The chitinized ring situated between the valves of the buccal capsule and the esophagus large and thick. Two tetragonal outer thickenings and 9 longitudinal ribs on each valve. All longitudinal ribs have a thickening and on each thickening is a small but distinct spine. Tridents well developed, but the median branch very small. Ends of branches pointed. Three valves at the connection of esophagus and intestine. Intestine as wide as posterior part of esophagus. Rectum 0.05 mm long in the female. Three rectal glandular cells at the connection between intestine and rectum.

123 Nerve ring surrounding anterior part of esophagus in its narrowest part. Lateral cervical papillae small, thin, and pointed, situated at the level of the anterior part of the esophagus.

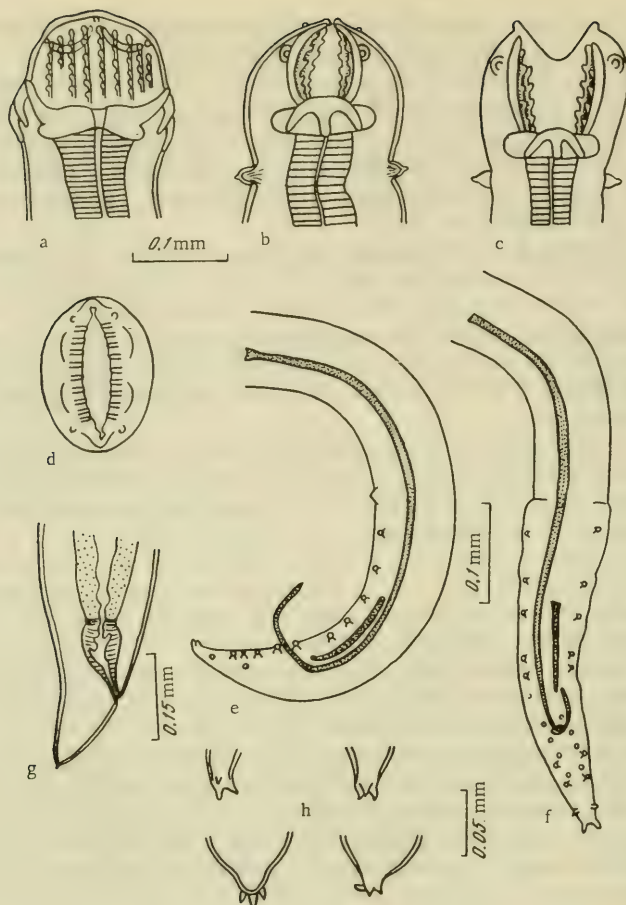


FIGURE 67. *Zeylanema anabantis* (Pearse, 1933):

a — cephalic end, lateral; b, c — same, ventral; d — same, apical; e — caudal end of male, lateral; f — same, ventral; g — caudal end of female, lateral; h — processes on tail of females (after Yeh, 1960c).

Male. Length 10.9 mm, width 0.124 mm. Cephalic end blunt, caudal end pointed. Valves of buccal capsule 0.09 mm long, 0.1 mm wide. Chitinized ring 0.07 mm wide. Median branch of trident 0.029 mm long, lateral branches 0.079 mm. Length of esophagus 0.85 mm, club-shaped muscular anterior part 0.73 mm long, cylindrical glandular posterior part 0.48 mm. Nerve 124 ring situated 0.17 mm, cervical papillae 0.21 mm from cephalic end.

Tail curved ventrally. A small depression (which may be the outline of the developing sucker) situated 0.43 mm from the posterior end. Caudal wings absent. Tail 0.058 mm long. Lips of cloaca protruding. Sixteen pairs of sessile caudal papillae, 14 pairs precloacal and 2 pairs postcloacal. Only the right spicule present, 0.63 mm long, weakly chitinized, thin, and difficult to see; its proximal end wide and bifid, the distal end thin and pointed. The single testis is curved around the anterior end of the intestine.

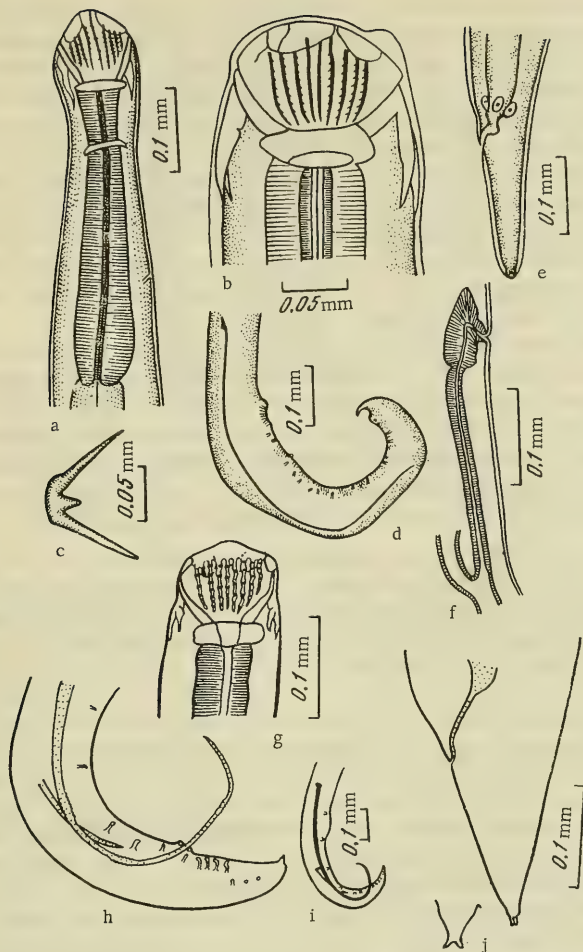


FIGURE 68. *Zeylanema anabantis* (Pearse, 1933):

a — anterior end of male, lateral; b — cephalic end of female, lateral; c — trident;
d — caudal end of male, lateral; e — caudal end of female, lateral; f — region of
vulva, lateral; g — cephalic end, lateral; h, i — caudal end of male, lateral; j — caudal
end of female, lateral (a — f — after Khera, 1954; g — j — after Fernando and Furtado,
1963b).

Female. Length 16.3–17.2 mm, width 0.2–0.225 mm. Cephalic end blunt, caudal end pointed. Valves of buccal capsule 0.080–0.085 mm long, 0.137–0.14 mm wide. Chitinized ring 0.082–0.090 mm wide. Median branch of trident 0.020–0.024 mm long, lateral branches 0.086–0.093 mm. Length of esophagus 1.45–1.47 mm, its club-shaped muscular anterior part 0.57 mm long, cylindrical glandular posterior part 0.88–0.90 mm. Nerve ring situated 0.18–0.217 mm, cervical papillae 0.23 mm from cephalic end.

Tail 0.186–0.190 mm long, tapering, pointed. Vulva situated before middle of body, 6.77 mm from the anterior end in a specimen 16.3 mm long. Its lips indistinct. Ovejector situated near the vulva, large, with thick

muscular walls, 0.24 mm long. Two opposite uteri. A single anterior ovary, curved around the end of the intestine. Posterior part of uterus with blind end.

Buccal valves with 9 longitudinal denticulate ribs, the median ribs extending along the whole valves. One or two of the lateral ribs shorter than the others. Pharynx short, sclerotized. Esophagus divided into a muscular part and a glandular part. Tridents distinct.

Male. Length 5.94–6.72 mm, width 0.208–0.216 mm. Buccal capsule 0.072–0.079 mm long and 0.101 mm wide. Pharynx 0.021 mm long, 0.072 mm wide. Muscular part of esophagus 0.352 mm long, 0.108–0.112 mm wide; glandular part 0.608 mm long, 0.112 mm wide. Nerve ring surrounding muscular part of esophagus 0.126–0.162 mm from its anterior end, 0.216–0.270 mm from the cephalic end.

Tail conical, curved ventrally, with pointed end. Cloaca situated 0.101–0.108 mm from end of tail. Six pairs of precloacal and 8 pairs of postcloacal papillae, one pair immediately before and one pair immediately behind the cloaca. Spicules of different length, weakly sclerotized, 0.88–1.08 and 0.252 mm long. The number of postcloacal papillae is larger than described by Yeh, but their arrangement is the same. Two pairs of small processes at the posterior end which were not mentioned by Yeh (1960).

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 25; Chakravarty, 1939, pp. 317–318; Fernando and Furtado, 1963, pp. 64, 153; Khera, 1954, pp. 100–103; Kulasiri and Fernando, 1956, pp. 420–424; Pearse, 1933, pp. 182–183; Yeh, 1960b, pp. 107–110; 1960c, pp. 117–124.

126 *Zeylanema atridentus* (Khera, 1954) Yeh, 1960
(Figure 69)

Synonym: *Camallanus atridentus* Khera, 1954

Host: *Ophiocephalus punctatus*.

Localization: intestine.

Distribution: India.

Description (after Khera, 1954). Cuticle with fine transverse striation. Buccal capsule wider than long, widest slightly behind its middle. Two lateral valves with two outer thickenings and 20 longitudinal ribs on the inside. Longitudinal ribs simple, smooth, and very thin. A ring of fine denticles at the base of the chitinized buccal capsule. Tridents absent. Esophagus divided into a shorter club-shaped muscular anterior part and a cylindrical glandular posterior part. Three valves at the connection between esophagus and intestine. Intestine as wide as posterior part of esophagus. Lumen of intestine narrow. Rectum short and narrow. Three rectal glands at the connection between the intestine and the rectum.

Male. Length 4.2–4.9 mm, width 0.077–0.108 mm. Anterior end blunt, posterior end pointed. Valves of buccal capsule 0.031–0.0345 mm long, 0.039–0.048 mm wide. A large, thick, chitinized ring 0.035–0.045 mm wide at the connection between buccal capsule and esophagus. Length of esophagus 0.64–0.71 mm, length of muscular part 0.22–0.24 mm, of glandular part 0.41–0.48 mm.

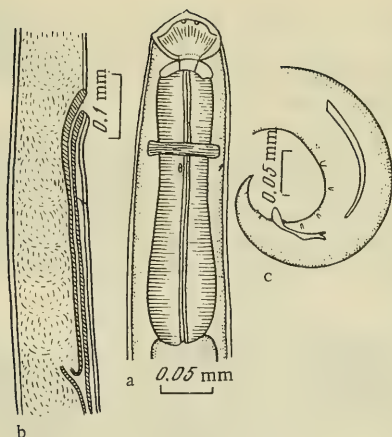


FIGURE 69. *Zeylanema atridentus* (Khera, 1954):

a — anterior end; b — region of vulva, lateral; c — caudal end of male, lateral (after Khera, 1954).

Nerve ring surrounding anterior part of esophagus 0.083–0.086 mm from the cephalic end. Cervical papillae situated 0.096–0.1 mm behind the nerve ring. Excretory pore medioventral, situated at level of cervical papillae.

127 Posterior end curved ventrally. Tail 0.065–0.068 mm long, tapering. Caudal wings and sucker absent. Ten pairs of ventral pedunculate caudal papillae, 5 pairs precloacal, 2 pairs cloacal, and 3 pairs postcloacal. The third and fourth pairs of precloacal papillae are situated close together. The two pairs of cloacal papillae are also situated close together. Spicules weakly and not completely chitinized. Right spicule longer than left, simple and thin, 0.156 mm long. Left spicule thick, divided at the base and widening before the distal end, 0.07 mm long. The single testis has the form of an "8" and is situated around the anterior end of the intestine.

Female. Length 7.6–9.1 mm, width 0.11–0.124 mm. Anterior end blunt, posterior end very thin. Valves of buccal capsule 0.040–0.045 mm long, 0.063–0.068 mm wide. A large, thick, chitinized ring 0.052 mm wide at the connection between buccal capsule and esophagus. Length of esophagus 0.74–0.85 mm, length of muscular part 0.21–0.27 mm, of glandular part 0.53–0.58 mm.

Nerve ring surrounding anterior part of esophagus 0.097–0.126 mm from the cephalic end. Cervical papillae situated behind the nerve ring 0.11–0.135 mm from the cephalic end. Excretory pore medioventral, situated at level of cervical papillae.

Tail 0.22–0.30 mm long, tapering, its end very thin. Vulva situated before middle of body, 3.5 mm from the cephalic end in a specimen 8 mm long. Vulva with protruding lips. Vagina narrow, muscular, 0.46–0.55 mm long, extending posteriorly. The two uteri are opposite and filled with larvae. Posterior branch of uterus ending blind. There is a single anterior ovary coiled around the anterior end of the intestine. Larvae thick, 0.124–0.140 mm long.

References: Khera, 1954, pp. 103–106; Yeh, 1960b, pp. 117–120.

Zeylanema fernandoi Yeh, 1960 (Figure 70)

Hosts: *Ophiocephalus punctatus*, *O. striatus*.

Localization: intestine.

Distribution: Ceylon.

Description (after Yeh, 1960b). Three females examined. They are rather thick and short. Buccal valves with 9 longitudinal ribs. The 7 median 128 ribs have a tooth posteriorly. The posterior part of the buccal capsule narrows rapidly and then widens before the connection with the esophagus.

Tridents well developed. Cervical papillae very small.

(127)

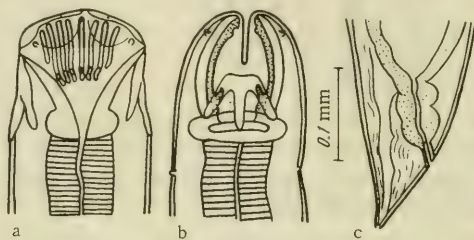


FIGURE 70. *Zeylanema fernandoi* Yeh, 1960:

a — cephalic end, lateral; b — same, ventral; c — caudal end of female, lateral (after Yeh, 1960b).

Male unknown.

Female. Length 2.9–5.4 mm, width 0.14–0.27 mm. Length of buccal capsule 0.10–0.11 mm, dorsoventral width 0.10–0.12 mm. Length of muscular anterior part of esophagus 0.36–0.40 mm, of posterior part 0.52–0.65 mm. Cervical papillae situated 0.16–0.18 mm, nerve ring 0.19–0.21 mm from the cephalic end. Vulva situated slightly behind middle of body. Tail 0.1 mm long.

Reference: Yeh, 1960b, pp.114–115.

Zeylanema kulasirii Yeh, 1960 (Figure 71)

Hosts: *Anabas testudineus*, *Ophiocephalus punctatus*.

Localization: intestine.

129 Distribution: Ceylon.

Description (after Yeh, 1960b). Buccal valves with 9 longitudinal rows of denticles only in the anterior 2/3 of the valves. A pair of rudimentary tridents present.

Male. Length 1.8–2.6 mm, width 0.07 mm. Length and dorsoventral width of buccal cavity 0.05 mm. Muscular anterior part of esophagus 0.23–0.26 mm long, posterior part 0.27–0.34 mm. The thin, ventrally curved tail ends in two finger-shaped processes. Caudal wings distinct. Six pairs of precloacal papillae, one median pair just before the cloaca, 6 pairs of post-cloacal papillae, the first pair situated just behind the cloaca. A pair of phasmids present. Spicules weakly sclerotized (difficult to measure). Left spicule 0.15–0.19 mm long, right spicule 0.40–0.42 mm long.

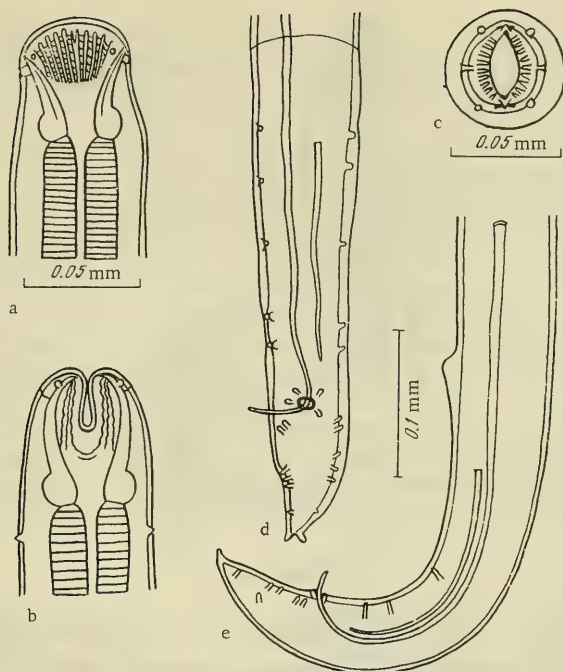


FIGURE 71. *Zeylanema kulasirii* Yeh, 1960:

a — cephalic end, lateral; b — same, ventral; c — same, apical; d — caudal end of male, ventral; e — same, lateral (after Yeh, 1960c).

Reference: Yeh, 1960b, pp.112–114.

***Zeylanema mastacembeli* Sahay and Sinha, 1966**
(Figure 72)

Host: *Mastacembelus armatus*.

Localization: intestine.

Distribution: India.

Description (after Sahay and Sinha, 1966b). Thin, threadlike, medium-sized nematodes, blood-red in life, cuticle not striated. The buccal valves are wider than long in males, as wide as long in females. Valves with two outer thickenings and 9 longitudinal moniliform ribs. Tridents distinct, the three branches of almost the same length, with blunt end.

Male. Length 11.60 mm, width 0.208 mm. Size of buccal valves, without the posterior chitinized ring, 0.088–0.096×0.112–0.128 mm. Chitinized ring situated at the connection between valves and esophagus, 0.072–0.088 mm wide. Club-shaped muscular anterior part of esophagus 0.528–0.560 mm long. Median branch of tridents 0.036–0.05 mm long, lateral branches 0.058–0.084 mm. Nerve ring situated 0.32–0.336 mm from the cephalic end. Tail, conical, blunt, pointed, curved ventrally, 0.096 mm long.

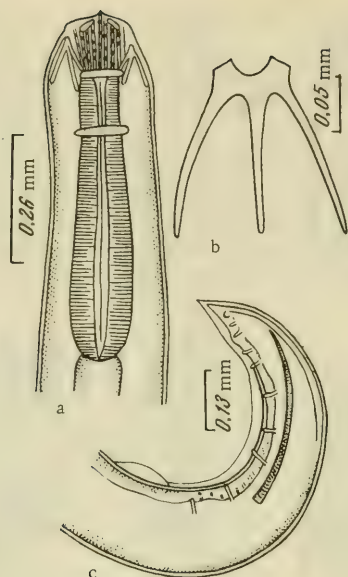


FIGURE 72. *Zeylanema mastacembeli* Sahay and Sinha, 1966:

a — anterior end, lateral; b — trident; c — caudal end of male, lateral (after Sahay and Sinha, 1966b).

Eleven pairs of pedunculate papillae in the region of the cloaca, 7 pairs precloacal, 2 pairs on the protruding lips of the cloaca, and the other 2 pairs postcloacal. A protruding cuticular tubercle is situated before the cloaca, 0.384 mm from end of tail. Caudal wings present. Only the right spicule recognizable, weakly chitinized, difficult to see, 0.336 mm long.

Female. Length 19.2–26.28 mm, width 0.224–0.272 mm. Size of buccal valves, without the posterior chitinized ring, $0.103\text{--}0.112 \times 0.123\text{--}0.128$ mm. The chitinized ring is situated at the connection between valves and esophagus, 0.075–0.084 mm wide. Club-shaped muscular anterior part of esophagus 0.576 mm long. Median branch of trident 0.084 mm long, lateral branches 0.083–0.089 mm. Nerve ring situated 0.232–0.238 mm from the cephalic end.

Tail tapering, with bluntly pointed end, 0.21–0.22 mm long. Vulva situated 6.768–9.28 mm from the anterior end (i. e. at the anterior third of the body). Vagina muscular, long, uterus with two opposite branches. Viviparous.

Reference: Sahay and Sinha, 1966b, pp. 247–252.

Zeylanema pearsei Yeh, 1960 (Figure 73)

Synonym: *Camallanus anabantis* Pearse, 1933 (in part)

Hosts: *Rasbora daniconius*, *Anabas testudineus*.

Localization: intestine.

Distribution: Ceylon, Singapore.

Historical review (see *Z. anabantis*).

Description (after Yeh, 1960). Buccal valves with 7 rows of teeth. Tridents absent.

Female. Length 5.1 mm, width 0.15 mm. Length of buccal cavity 0.08 mm, width (dorsoventral) 0.007 mm. Length of muscular anterior part of esophagus 0.36 mm, of glandular posterior part 0.52 mm. Tail 0.11 mm long. Tail with three distinct terminal spines. Vulva situated slightly before middle of body, dividing the body at the ratio of 1:1.2.

Description (after Pearse, 1933). Body transversely striated. Buccal capsule with a pair of valves, each with 7–10 ribs.

Female. Length 4.1 mm, width 0.09 mm. Tail conical, 0.12 mm long, with two or three small spines. Vulva situated slightly behind middle of body. The uterus of some specimens contained larvae.

Description (after Fernando and Furtado, 1963a, b). Relatively large forms. Buccal valves sclerotized in both sexes, with 7 longitudinal denticulate ribs. Pharynx weakly chitinized; behind it extends the muscular esophagus, which passes into the glandular esophagus. Tridents absent.

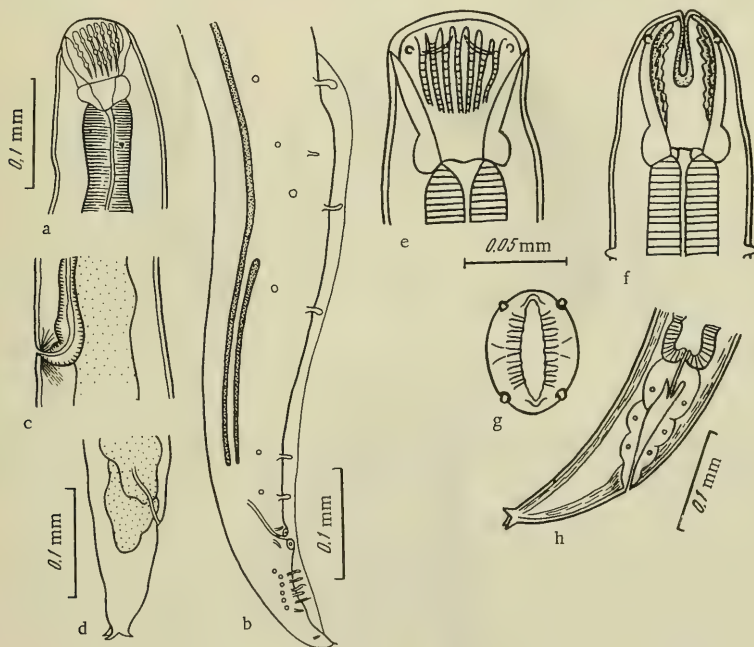


FIGURE 73. *Zeylanema pearsei* Yeh, 1960:

a — cephalic end, lateral; b — caudal end of male, lateroventral; c — region of vulva, lateral; d — caudal end of female, lateral; e, f, g — cephalic end, different aspects; h — posterior end of female, lateral (a — d — after Fernando and Furtado, 1963b; e — h — after Yeh, 1960b).

Male (one damaged specimen). Tail conical, curved ventrally, with pointed end. A small tubercle near end of tail. Cloaca situated 0.100 mm

from end of tail. Eight pairs of precloacal and 8 pairs of postcloacal papillae, one pair situated just before and one pair just behind the cloaca. The second pair of precloacal papillae is very small. Spicules weakly chitinized, of different length. Left spicule 0.155 mm long, right spicule 0.880 mm.

Female. Length 3.680 mm, width 0.096 mm. Length of buccal capsule 0.063 mm, width (dorsoventral) 0.074 mm. Length of pharynx 0.022 mm, width 0.056 mm. Length of muscular part of esophagus 0.304 mm, width 0.056 mm. Length of glandular part of esophagus 0.480 mm, width 0.056 mm. Nerve ring surrounding muscular part of esophagus 0.130 mm from its anterior end or 0.222 mm from the cephalic end. Tail conical, ending in three finger-shaped processes. Anus situated 0.096 mm from end of tail.

- 132 Vulva situated slightly behind middle of body, dividing the body at the ratio of 1:1.05.

References: Fernando and Furtado, 1963a, pp. 62–64; 1963b, pp. 141–163; Pearse, 1933, pp. 182–183; Yeh, 1960b, pp. 111–112.

Zeylanema spinosa Furtado, 1965 (Figure 74)

Host: *Betta picta*.

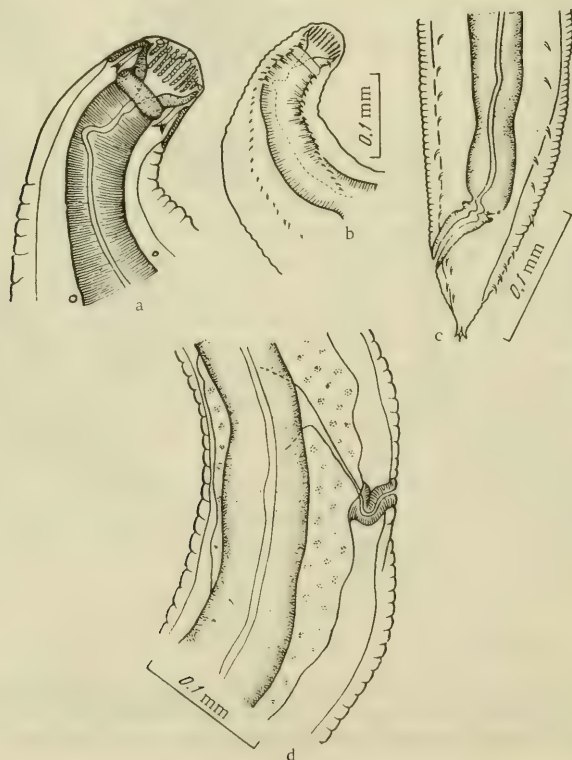


FIGURE 74. *Zeylanema spinosa* Furtado, 1965:

a, b — cephalic end; c — caudal end of female, lateral; d — region of vulva, lateral (after Furtado, 1965).

Localization: intestine.

Distribution: Malaysia.

Description (after Furtado, 1965). Large, spindle-shaped nematodes, with finely transversely striated cuticle. Cuticle with 4 longitudinal rows of cuticular spines with irregular intervals, two rows on each side. Buccal capsule with two strongly sclerotized lateral valves, with 9 longitudinal denticulate ribs (each rib with about 7 hooks). The median ribs extend along the whole buccal valve; the lateral ribs are markedly shorter. Pharynx strongly sclerotized; behind it extend the straight, club-shaped muscular part and the straight, cylindrical glandular part of the esophagus. A pair of tridents present, about 0.03 mm long.

Male unknown.

Female. Length 6.996 mm, width 0.231 mm. Buccal capsule 0.054 mm long and 0.057 mm wide (dorsoventral). Length of pharynx 0.012 mm, width 0.048 mm. Length of muscular part of esophagus 0.231 mm, width 0.066 mm. Glandular part of esophagus 0.891 mm long and 0.072 mm wide. Nerve ring surrounding muscular esophagus 0.180 mm from its anterior end or 0.240 mm from the cephalic end. Tail conical, short, ending in three processes. Anus situated 0.099–0.132 mm from end of tail. Vulva situated before middle of body, dividing the body at the ratio of 1.0:1.4. Lips of vulva protruding.

Reference: Furtado, 1965, pp. 677–680.

Zeylanema sweeti (Moorthy, 1937) Yeh, 1960 (Figures 75, 76)

Synonyms: *Camallanus sweeti* Moorthy, 1937; *Paracamallanus ophiocephali* Karve, 1941

Hosts: definitive — *Ophiocephalus gachua*; intermediate — *Cyclops* (= *Mesocyclops*) *leuckarti*, *C. hyalinus*; reservoirs — *Barbus puckelli*, *B. ticto*, *Lepidocephalichthys thermalis*, *Gambusia* sp.

Localization: intestine (in definitive host), wall of intestine (in reservoirs), body cavity (in intermediate hosts).

Distribution: India.

Description (after Moorthy, 1937b). Stoma 0.06–0.07 mm long, with two valves. A wide chitinized ring separates the valves from the esophagus. The 9 longitudinal moniliform ribs are of about the same length. They extend from the anterior end to the chitinized ring. Mouth wide, surrounded by an inner ring of 2 pairs of small papillae and an outer ring of 2 pairs of larger papillae. Amphids indistinct. Tridents present, the median branch about 0.046 mm long, the two submedian branches 0.015 mm long. Two quadrilateral chitinized plates at the anterior margin of the buccal valves.

Male. Length 3.0–3.9 mm, width 0.13 mm. Muscular anterior part of esophagus 0.31–0.38 mm long, glandular posterior part 0.38–0.44 mm. Tail 0.05–0.063 mm long; in immature forms there are tubercles at the end of tail as in the females; in mature males there is only one ventrolateral, median tubercle which is markedly reduced and resembles a small teatlike process. Thirteen to 15 pairs of genital papillae; 4–6 pairs preanal (5 pairs in most specimens), 2 pairs circumanal, and 7 pairs postanal. The first two pairs of postanal papillae are lateral and form a group, the third pair is

134 ventrolateral and isolated, and the sixth and seventh pairs are ventrolateral and arranged in a group; the circumanal papillae are isolated. The position of the preanal papillae varies from subventral to ventrolateral. Spicules of different length: right spicule 0.21–0.30 mm long, left spicule thinner, 0.1–0.18 mm long. A suckerlike organ situated 0.32 mm from end of tail.

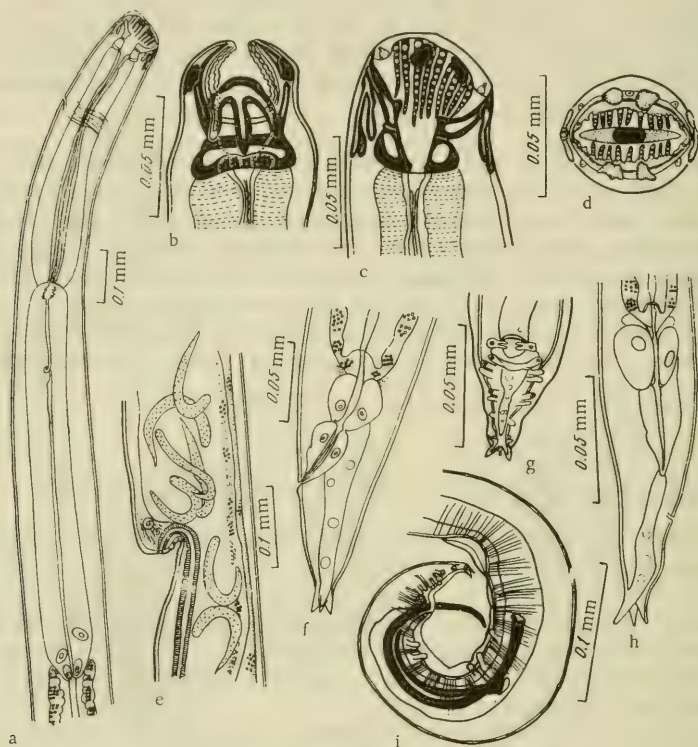


FIGURE 75. *Zeylanema sweeti* (Moorthy, 1937):

a — anterior end, lateral; b, c, d — cephalic end, different aspects; e — region of vulva, lateral; f, h — caudal end of female, different aspects; g, i — caudal end of male, different aspects (after Moorthy, 1937b).

Female. Length 3.2–5.5 mm, width 0.15 mm. Cuticle finely striated with intervals of 0.004 mm. Muscular anterior part of esophagus 0.32–0.42 mm long, glandular posterior part 0.4–0.52 mm. Nerve ring situated between anterior and middle third of muscular part of esophagus, excretory pore situated 0.14 mm from the cephalic end. Vulva situated 2.0–3.0 mm from the anterior end, with distinct, protruding lips. Posterior lip displaced laterally by an anteriorly directed process; such a process is usually not present in young, unfertilized females. Vagina narrow, extending posteriorly for about 0.3 mm. Tail with three tubercles at the end, 0.05–0.07 mm long; the tubercles are distinct in immature forms, the mediodorsal process markedly longer and thicker than the two ventrolateral processes. In mature specimens the processes are less distinct and of about the same length.

Description (after Baylis, 1939). Cuticle transversely striated with intervals of 0.004 mm. Buccal valves 0.06–0.07 mm long (including basal ring). Valves with 9 inner longitudinal denticulate ribs and two rectangular outer thickenings. Median branch of tridents about 0.046 mm long, lateral branches about 0.025 mm. Anterior part of esophagus 0.31–0.42 mm long, posterior part 0.38–0.52 mm. Nerve ring situated at anterior third of anterior part of esophagus, the excretory pore (in females) about 0.16 mm from the anterior end.

Male. Length 3.0–3.9 mm, width 0.13 mm. Tail 0.050–0.063 mm long. Three almost equal terminal spines in immature specimens. In mature males the median spine is very small and the two ventrolateral spines are larger. Thirteen to 15 pairs of caudal papillae, 4–6 pairs preanal (5 pairs in most specimens), one pair adanal, and 8 pairs postanal. The first and second pairs from the posterior end are lateral and arranged in a group, the third pair is ventrolateral and isolated, the fourth and fifth pairs are ventrolateral in a group, the sixth and seventh pairs are ventrolateral in a group, and the eighth and ninth pairs are circumanal, isolated. The position of the preanal papillae varies from subventral to ventrolateral. A sucker-like organ present about 0.32 mm from the posterior end. Right spicule 0.21–0.3 mm long. Left spicule markedly thinner, 0.1–0.18 mm long.

Female. Length 3.2–3.5 mm, width 0.15 mm.

Tail 0.05–0.07 mm long, with three spines at the end. Vulva situated 2–3 mm from the anterior end, with protruding lips. In fertilized females the anterior lip is displaced laterally by the overlapping posterior lip and forms a lateral process. Vagina narrow, extending posteriorly for about 0.3 mm.

According to Moorthy (1937b, 1938b), the first intermediate host of this species is *Cyclops leuckarti* or *C. hyalinus*, the second intermediate host small fish (*Barbus puckelli*, *B. ticto*, *Lepidocephalichthys thermalis*) which are eaten by the definitive host. Larvae were also found in *Gambusia* sp., which had been introduced from Italy for the control of *Cyclops*. The larvae are encysted in the wall of the intestine in the second host. The definitive host, *Ophiocephalus gachua*, has an infection rate of 95% in India.

The larvae are released into the intestine of the definitive host and then discharged into the water and swallowed by *Cyclops*. Passage of the larvae into the body cavity of *Cyclops* takes place 2–3 hours after infection. Twenty-four to 36 hours later these larvae undergo the first molt. The second molt takes place 5–12 days later, depending on the temperature. *Cyclops* swallowed by fish are killed by the digestive juices, particularly bile, and the larvae become active. The third molt apparently takes place 136 at this time. The larvae later enter the definitive host, which eats the fish that feed on *Cyclops*. The fourth molt takes place in the intestine. When the parasites become mature, copulation takes place probably in the anterior part of the intestine, where the largest concentration of males and females is found. Fertilized females migrate to the posterior part of the intestine, and the larvae hatch here and are discharged into the water with the feces. They are then swallowed by *Cyclops*. The presence of third-stage larvae in the intestine of the definitive host (*Ophiocephalus*) suggests that direct infection may have taken place, although the larvae may have reached the intestine together with fish. Adult nematodes were found only in *Ophiocephalus*.

Biology (after Moorthy, 1938b). *Mesocyclops leuckarti* and *M. hyalinus* were used in experiments; adult females of *M. leuckarti* were most easily infected. The infection rate reached 75% in one experiment. Four to 6 hours after the larvae are swallowed, they penetrate into the body cavity, where they develop further. One *Cyclops* may contain 12–15 larvae. Such specimens are sluggish and tend to sink to the bottom of the vessel. Infected *Cyclops* survived to 52 days in the laboratory at 50–56.5° and to 70 days at 30.5–38.5°.

Fresh bile of *Ophiocephalus* kills *Cyclops* in 8 minutes and activates the larvae. The larvae leave the *Cyclops* through the antennae, legs, and the boundary of cephalothorax and abdomen. After they reach the furca or oral segment, the larvae perforate the cuticle by rotatory movements of the cephalic end. Only in 3 out of 108 cases did larvae emerge from the anal segment. The larvae emerged after 50 minutes to 2 hours. Larvae which did not emerge died after 3–4 hours of active movement. Hydrochloric acid in a solution of 0.1–1.0% killed the *Cyclops* in 2–3 minutes, but activity of the larvae was weak. The yield of larvae under laboratory conditions was small: only 7 larvae were obtained from 140 infected *Cyclops*.

Third-stage larvae were found in the following naturally infected fish: *Barbus puckelli*, 20%; *B. ticto*, 15%; *Lepidocephalichthys thermalis*, 90%; *Gambusia* sp., 5%. The larvae found in *B. ticto* and in *Gambusia* sp. were identical with the larvae of *Z. sweeti* from experimentally infected *Cyclops*.

Moorthy gives the following description of the different stages of development of *Z. sweeti*:

First-stage larva. Length 0.19–0.28 mm, width 0.12–0.018 mm. Adorsal triangular denticle present at the anterior end. Amphids in the form of openings. Nerve ring situated 0.025–0.045 mm and genital primordium 0.11–0.17 mm from the cephalic end. Phasmids large, saclike, situated slightly behind the anus. Tail 0.033–0.046 mm long, with blunt end. Immediately after the first molt, which takes place 24–36 hours after entry into the body cavity of *Cyclops*, the larvae lose the triangular denticle.

Second-stage larva. The stoma becomes distinct and rectangular at this stage. Excretory pore distinct, situated slightly behind the nerve ring. After the second molt, which takes place after 5–7 days at high temperatures and after 8–12 days at moderate temperatures (see above), the stoma becomes partly chitinized and differentiated. The outer ring of papillae, consisting of two pairs, now becomes recognizable. The genital primordium consists, as at the preceding stage, of four cells. Its length remains unchanged but it is twice as wide. Three characteristic pointed processes appear at the end of the tail (under the exuvia).

137 Third-stage larva (from experimentally infected *Cyclops*). Buccal capsule partly chitinized and incompletely differentiated from the esophagus by chitinized valves. Eight to 11 partly chitinized moniliform ribs of almost equal length extend from the anterior margin of the buccal valve. The genital primordium consists of 8 cells. The mediodorsal caudal process is markedly more massive than the others.

138 Larvae of this stage from the intestine of naturally infected fish (*B. puckelli* and *L. thermalis*) are, at a later stage of development, almost one and a half times as long as specimens obtained from *Cyclops*. Chitinization of the buccal apparatus is complete.

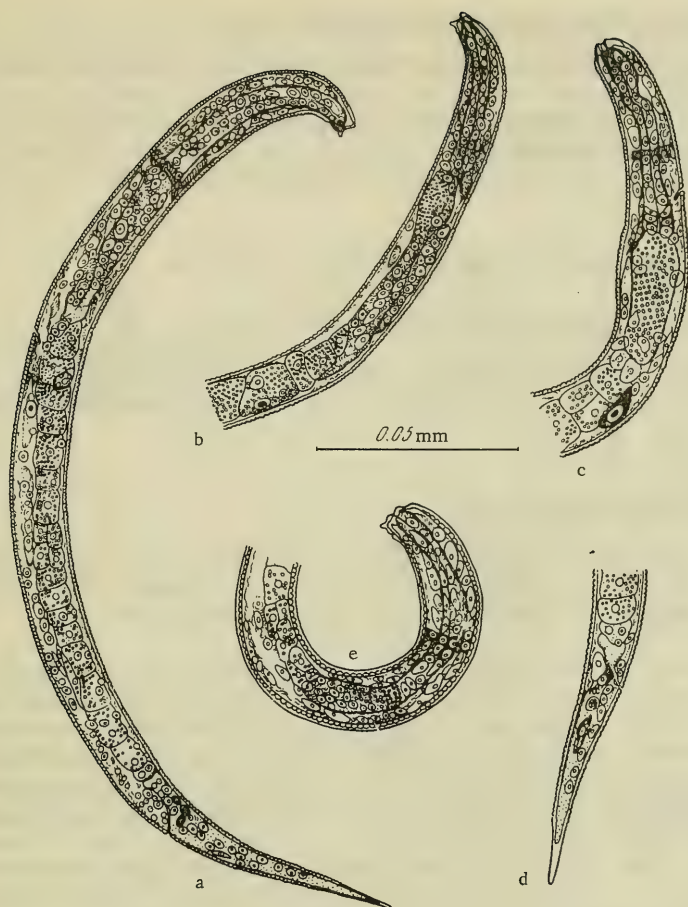


FIGURE 76. *Zeylanema sweeti* (Moorthy, 1937):

a — first-stage larva, general view; b — anterior end of first-stage larva; c — anterior end of second-stage larva; d — same, posterior end; e — anterior end of larva during first molt (after Moorthy, 1938).

Larvae were not examined during the third molt.

Fourth-stage larva (after the fourth molt, from the intestine of naturally infected *Ophioccephalus*). The fourth stage was determined by the degree of development of the genital primordium and the presence of a vulva. The stoma resembles that of the adult. The sex is easily determined.

Fifth-stage larva (female). Anterior and posterior parts of uterus developed. Anterior part ending in a long tubular ovary, posterior part with a small, rudimentary ovary.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 28; Baylis, 1939, pp. 212–214; Karve, 1941, pp. 34–37; Moorthy, 1937, pp. 302–306; Moorthy, 1938, pp. 323–342; Yamaguti, 1961b, p. 43; Yeh, 1960b, pp. 107–116.

SUBFAMILY *PROCAMALLANINAE* YEH, 1960

Synonym: *Neocamallaninae* Chakravarty and Majumdar, 1960

Diagnosis. *Camallanidae*. Buccal capsule entire, with or without thickenings; tridents absent.

Type genus: *Procamallanus* Baylis, 1923.

Key to the genera of the subfamily *Procamallaninae*

- 1 (2). Buccal capsule with spiral thickenings *Spirocamallanus* Olsen, 1952.
- 2 (1). Buccal capsule smooth, without spiral thickenings *Procamallanus* Baylis, 1923.

Genus *Procamallanus* Baylis, 1923

Synonyms: *Cucullanus* Müller, 1777 (in part); *Camallanus* Railliet and Henry, 1915 (in part); *Thelazo* Pearse, 1933 (?); *Indo-camallanus* Chakravarty, Majumdar and Sain, 1963

Diagnosis. *Procamallaninae*. Buccal capsule with rounded cross section, usually longer than wide, widest in the middle. Capsule sometimes as long as wide. Inner surface of capsule smooth. Mouth usually hexagonal, with 6 rudimentary processes at its margin. Cephalic end with 4 large submedian papillae and amphids which are situated slightly nearer the mouth than the papillae. Esophagus divided into a muscular anterior and a glandular posterior part.

Male. Tail conical; caudal wings present. Nine pairs of riblike pre-anal papillae. Adanal and postanal papillae present. Right spicule sometimes with wings. Gubernaculum usually absent.

Female. Vulva situated before middle of body. Posterior ovary absent. Viviparous. A group of teatlike appendages of varying number at the end of the tail.

Parasites of the stomach and intestine of fish and amphibians. Larvae found in Copepoda.

Type species: *Procamallanus laeviconchus* (Wedl, 1862) Railliet and Henry, 1915.

139 *Procamallanus laeviconchus* (Wedl, 1862)
(Figure 77)

Synonyms: *Cucullanus laeviconchus* Wedl, 1862; *Camallanus laeviconchus* (Wedl, 1862) Railliet and Henry, 1915

Hosts: *Synodontis schaal*, *Bagrus bayad*.

Localization: intestine.

Distribution: North Africa.

Description (after Baylis, 1923a). Cuticle coarsely striated with intervals of 0.020 mm. Width of cephalic end at the widest part of the buccal capsule 0.06–0.08 mm. Buccal capsule 0.0675–0.07 mm long, 0.0425–0.06 mm wide. Esophagus consisting of a muscular anterior part and a long glandular posterior part. Nerve ring situated 0.175–0.2 mm, excretory pore 0.43 mm (female) from the cephalic end.

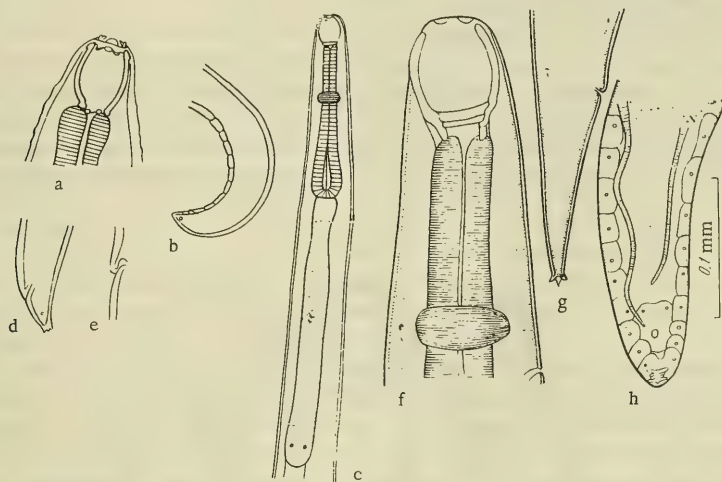


FIGURE 77. *Procammallanus laeviconchus* (Wedl, 1862):

a — cephalic end; b — caudal end of male, lateral; c — anterior end; d — caudal end of female, lateral; e — region of vulva, lateral; f — anterior end; g — caudal end of female, lateral; h — caudal end of male, ventral (a — after Yorke and Maplestone, 1926; b — e — after Tornquist, 1931; f — h — after Campana-Rouget, 1961a).

Male. Length 3.65 mm, width 0.11 mm. Distance from cephalic end to posterior end of muscular part of esophagus 0.4 mm; length of esophagus 1 mm. Tail 0.037 mm long. Nine pairs of riblike preanal papillae (sometimes 8 or 10 papillae on one side and 9 on the other). One pair of papillae similar to the preanal papillae lateral to the cloaca. There are also apparently two small subventral pairs at the sides of the cloaca, one pair behind the other, and three small pairs of postanal papillae which are sometimes indistinct. Left spicule 0.05 mm long, right spicule 0.15 mm. Gubernaculum not found.

140 Female. Length 15.5 mm, width 0.35 mm. Distance from cephalic end to posterior end of muscular part of esophagus 0.47 mm, length of esophagus 1.25 mm.

Tail conical, tapering, ending in three short, blunt processes. Tail 0.15 mm long. Vulva with protruding anterior lip, situated slightly before middle of body (7 mm from anterior end in a specimen 15.5 mm long). Vagina at first narrow, winding posteriorly for about 1.1 mm before passing into the uterus, then gradually widening. Only one ovary. Posterior branch of uterus ending blind, about 1.4 mm from the posterior end. The loops of the ovary extend to 0.4–0.9 mm behind the connection between esophagus and intestine. Viviparous.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.30; Baylis, 1923a, pp.24-38; Yamaguti, 1961b, p.46.

Procamallanus armatus Campana-Rouget and Therezien, 1965
(Figure 78)

Host: *Anguilla australis*.

Localization: stomach.

Distribution: Madagascar.

Description (after Campana-Rouget and Therezien, 1965). Body tapering at both ends. Buccal capsule oblong, with smooth walls. Esophagus divided into a muscular and a glandular part. Tail conical, with processes in the female, short and forming a spiral in the male. Excretory pore and deirids situated at about the same level, slightly behind the nerve ring.

(141)

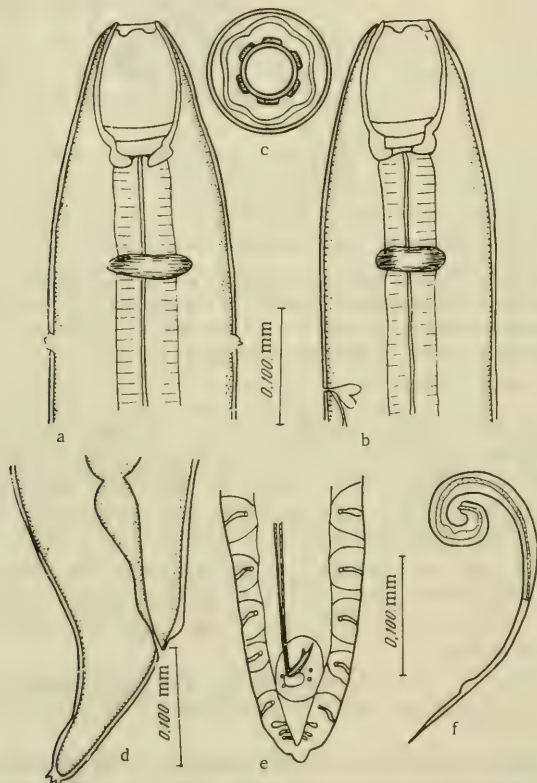


FIGURE 78. *Procamallanus armatus* Campana-Rouget and Therezien, 1965:

a — cephalic end, dorsoventral; b — same, lateral; c — same, apical; d — caudal end of female, lateral; e — caudal end of male, ventral; f — larva from uterus (after Campana-Rouget and Therezien, 1965).

Male. Length 5.65 mm, width 0.23 mm. Buccal capsule 0.120 mm long, 0.072 mm wide. Anterior part of esophagus 0.500 mm long, posterior part 0.665 mm. Nerve ring situated 0.210 mm, deirids 0.272 mm, excretory pore 0.318 mm from cephalic end. Eight pairs of preanal papillae almost equally spaced, their stalks embedded in the cuticle; 2 pairs of small adanal papillae near the cloaca; a group of postanal papillae consisting of a pair which resembles the preanal papillae, then smaller lateroventral papillae, the first pair distinctly separated from the others, and two or three indistinct pairs.

Right spicule 0.190 mm long, thin, strongly chitinized, widened in the form of a hook with a blunt process at the distal end so that the spicule looks like a harpoon. Left spicule absent.

Female. Length 8.8–13.25. Description of a specimen 12.93 mm long. Width at the vulva 0.35 mm. Buccal capsule 0.120 mm long and 0.092 mm wide, round in apical view, but appears like six regularly arranged festoons. Mouth round, surrounded by 6 small chitinous formations, two median, two lateroventral, and two laterodorsal. Outside the capsule there are four submedian papillae in the outer ring (papillae of inner ring not recognizable) 141 and two lateral amphids. Inner opening of buccal capsule slightly triangular.

Length of muscular part of esophagus 0.590 mm, of glandular part 0.800 mm. Anus situated in a posteriorly directed slit 0.150 mm from the conical end of the tail which bears three blunt processes.

Nerve ring situated 0.230 mm, deirids 0.260 mm, excretory pore 0.310 mm from cephalic end. Vulva situated slightly behind middle of body (7 mm from cephalic end), slightly protruding. Vagina short, directed anteriorly and joined by the two opposite branches of the uterus with thin walls, extending to the esophagus and the rectum, respectively, and containing numerous embryos with a thin tail, 0.400–0.410 mm long.

Reference: Campana-Rouget and Therezien, 1965, pp.165–170.

142 *Procamallanus aspiculus* Khera, 1955 (Figure 79)

Host: *Bagarius bagarius*.

Localization: intestine.

Distribution: India.

Description (after Khera, 1955).

Male. Length 4.8 mm, width 0.12 mm. Cuticle thin, transversely striated with intervals of 0.004–0.007 mm. Buccal capsule smooth except for platelike processes at the base. A crescent-shaped cuticular process on the inner surface of the dorsal side of the buccal capsule. Cuticular ring represented by two spinelike formations at the base of the buccal capsule. Two processes in the cavity of the capsule. Buccal capsule spherical, 0.075×0.075 mm. Esophagus divided into a club-shaped anterior part 0.27 mm long and a glandular posterior part also 0.27 mm long. Intestine with a narrow lumen. Nerve ring situated 0.15 mm, the small lateral cervical papillae 0.3 mm, and the excretory pore 0.32 mm from the cephalic end.

Tail curved ventrally, with conical end, 0.41 mm long. Caudal wings well developed. Six pairs of precloacal and 2 pairs of postcloacal pedunculate papillae. The peduncles of the precloacal papillae are larger than those of the postcloacal papillae. Spicules and gubernaculum absent. The single

testis is situated 0.25 mm behind the glandular part of the esophagus. It resembles a figure 8.

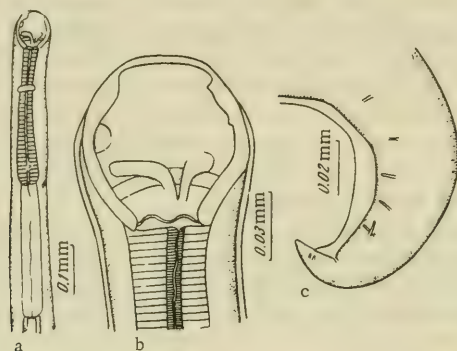


FIGURE 79. *Procammallanus aspiculus* Khera, 1955:

a — anterior end, lateral; b — cephalic end; c — caudal end of male, lateral (after Khera, 1955).

Female not known.

Reference: Khera, 1955, pp. 243—252.

143 *Procammallanus attui* Pande, Bhatia, and Rai, 1963
(Figure 80)

Host: *Wallago attu*.

Localization: body cavity.

Distribution: India.

Description (after Pande, Bhatia, and Rai, 1963b). Long, milk-white nematodes. Buccal capsule slightly yellowish brown, with smooth walls and with 4 oval chitinized plates, each with a fringe of 10—12 leaflike processes. Tail ending in 3 finger-shaped processes in both sexes.

Male. Length 7—22 mm, width 0.247—0.399 mm. Buccal capsule cup-shaped, 0.13—0.133 mm long and 0.095—0.152 mm wide. Length of esophagus 1.197—2.166 mm, length of muscular anterior part 0.627—1.026 mm, of glandular posterior part 0.57—1.14 mm. Nerve ring situated 0.34—0.361 mm, excretory pore 0.55—0.77 mm from cephalic end. Tail curved ventrally, with wide caudal wings which extend 2.18—2.32 mm anteriorly from the posterior end. Spicules of different length and form: right spicule longer and thicker, its anterior part wider and the posterior part narrowing, 0.27—0.28 mm long; left spicule needle-shaped, 0.1—0.17 mm long. Fifteen pairs of caudal papillae: 10 longer, riblike preanal pairs equally spaced and 5 postanal pairs, the last pair situated above the trifid end of the tail.

Female. Buccal capsule barrel-shaped, 0.247—0.25 mm long, 0.052—0.073 mm wide. Length of esophagus 1.11—3.34 mm, length of muscular anterior part 0.6—1.33 mm, of glandular posterior part 0.51—1.91 mm.

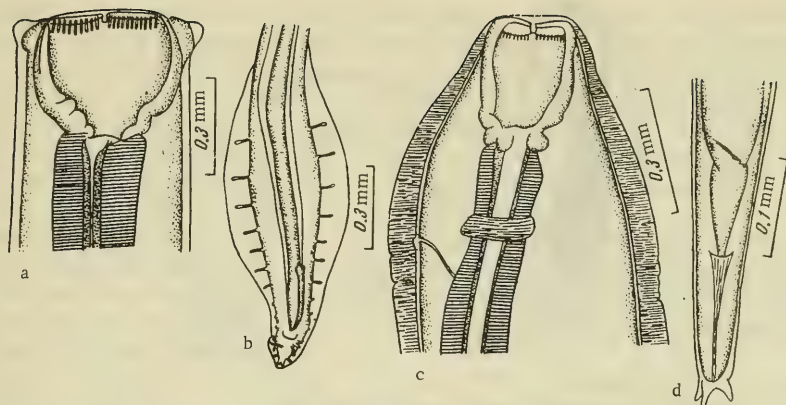


FIGURE 80. *Procammallanus attui* Pande, Bhatia, and Rai, 1963:

a — cephalic end of male; b — caudal end of male; c — cephalic end of female, lateral;
d — caudal end of female (after Pande, Bhatia, and Rai, 1963a).

144 Nerve ring situated 0.23–0.49 mm, excretory pore 0.29–0.95 mm from cephalic end. Genital opening without a swelling near the vulva, situated 2.36–11.0 mm before the caudal end. Tail 0.1–0.38 mm long, ending in 3 pointed processes.

Reference: Pande, Bhatia, and Rai, 1963b, pp.105–118.

Procammallanus brevis Kung, 1948 (Figure 81)

Host: frog.

Localization: intestine.

Distribution: South Africa.

Description (after Kung, 1948). Body narrowing in the posterior third, curved ventrally. Cuticle with distinct transverse striation. Mouth surrounded by 6 small papillae, four submedian and two lateral. The barrel-shaped buccal capsule is oblong and laterally compressed. Its walls are strongly chitinized, without ribs. The wall of the lower part of the capsule is thicker than that of the upper anterior part, and its strongly thickened posterior margin forms a ringlike connection with the anterior end of the esophagus. Cup-shaped cuticular processes project into the buccal capsule from its base.

Male. Length 1.75–1.85 mm, width 0.083–0.092 mm. Buccal capsule 0.09 mm long and 0.065 mm wide. Muscular anterior part of esophagus club-shaped, 0.165–0.170 mm long. Nerve ring situated 0.132 mm, excretory pore 0.172 mm from cephalic end. Tail blunt, curved ventrally. Caudal wings thin, about 0.32 mm long. Eight or 9 pairs of equally shaped preanal papillae. One pair of adanal papillae, 3 pairs of small circumanal papillae, and 4 pairs of postanal papillae, the last pair the largest, situated near the medioventral line. Between this last pair is a single sessile papilla. Right spicule 0.079–0.089 mm long, left spicule weakly chitinized, 0.039 mm long.

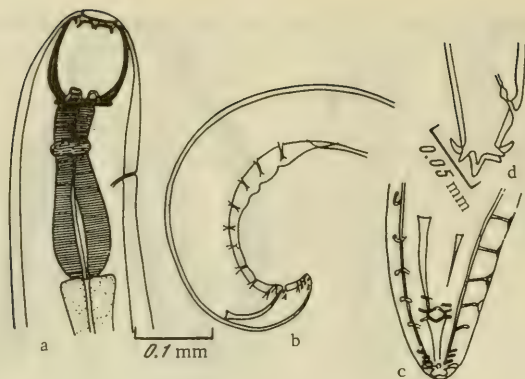


FIGURE 81. *Procammallanus brevis* Kung, 1948:

a — anterior end, lateral; b — caudal end of male, lateral; c — same, ventral;
d — caudal end of female, lateral (after Kung, 1948).

Female. Length 1.95–2.1 mm, width 0.15–0.175 mm. Length of club-shaped muscular anterior part of esophagus 0.198–0.22 mm. Nerve ring situated 0.016 mm from cephalic end, excretory pore situated behind it. Tail 0.016 mm long, ending in 5–7 spinelike processes. Vulva situated behind middle of body, usually 0.83–0.904 mm from posterior end. Vagina 0.51 mm long, extending posteriorly almost to the tail. Two branches of uterus, filled with numerous larvae.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 30; Kung, 1948, pp. 146–148.

Procammallanus chakravartyi (Chakravarty, Majumdar, and Sain, 1961) Fernando and Furtado, 1963 (Figure 82)

Synonyms: *Neocammallanus heteropneusti* Chakravarty, Majumdar, and Sain, 1961; *Indocammallanus heteropneusti* Chakravarty, Majumdar, and Sain, 1963

Host: *Heteropneustes fossilis*.

Localization: stomach.

Distribution: India.

Historical review

This species was described from *Heteropneustes fossilis* as *Neocammallanus heteropneusti*. However, the name *Neocammallanus* is preoccupied by Ali (1956), and the authors therefore proposed in 1963 to name it *Indocammallanus* and the new species *Indocammallanus heteropneusti*. The authors compared the genus *Indocammallanus* with the genus *Procammallanus*, from which it differs only in the presence of a gubernaculum; this seems insufficient to establish a genus in the Camallanidae, since the size and form of the spicules and gubernaculum vary in this family according to the degree of chitinization (Yeh, 1960b; Fernando and Furtado, 1963b).

Fernando and Furtado (1963) placed this species in the genus *Procamallanus*, but since there is a species *P. heteropneusti* Ali, 1956, they named it *Procamallanus chakravartyi*. The authors noted that three species of *Procamallanus* have been described from *Heteropneustes fossilis*: *P. spiculogubernaculus* Agrawal, 1938, *P. confusus* Fernando and Furtado, 1963, and *P. chakravartyi* Fernando and Furtado, 1963; these are probably the same species, but they are considered as valid species until further material becomes available.

Description (after Chakravarty, Majumdar, and Sain, 1961). Cuticle coarsely striated. Males smaller than females. Mouth forming a dorsoventral slit surrounded by a chitinized buccal capsule. Cephalic papillae and tridents absent. Esophagus divided into a club-shaped muscular anterior 146 part and a longer glandular part.

Male. Length 3.9–4.0 mm, width 0.120 mm. Length of buccal capsule 0.048–0.060 mm, width 0.036–0.048 mm. Esophagus divided into a muscular and a glandular part: length of muscular part 0.204–0.228 mm, width 0.072 mm; length of glandular part 0.36–0.44 mm, width 0.72 mm. Nerve ring situated 0.120–0.144 mm from cephalic end. The curved, conical tail has caudal wings. Tail 0.036–0.048 mm long. Fifteen pairs of pedunculate caudal papillae, one pair postanal. Only the right whiplike spicule present, 0.216–0.252 mm long. Gubernaculum consisting of three parts, two of them shorter than the third. The shorter parts apparently originate on the main stem; short parts 0.048 and 0.039 mm long, longer part 0.072 mm.

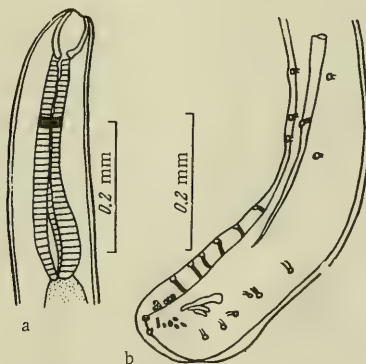


FIGURE 82. *Procamallanus chakravartyi* (Chakravarty, Majumdar, and Sain, 1961):

a — anterior end; b — caudal end of male (after Chakravarty, Majumdar, and Sain, 1961).

Female. Length 4.8–7.2 mm, width 0.156–0.168 mm. Length of buccal capsule 0.084–0.092 mm, width 0.060–0.068 mm. Esophagus divided into a muscular and a glandular part: length of muscular part 0.30–0.324 mm, width 0.048–0.072 mm; length of glandular part 0.336–0.540 mm, width 0.048–0.072 mm. Nerve ring situated 0.168–0.192 mm from cephalic end. Tail conical, without papillae, 0.096–0.132 mm long. Vulva situated near

middle of body, 2.4–3.3 mm from end of tail. Uteri opposite. Viviparous. Length of larvae 0.264–0.272 mm, width 0.024–0.028 mm.

References: Chakravarty, Majumdar and Sain, 1961, pp. 221–224; Chakravarty, Majumdar, and Sain, 1963, pp. 415–416; Fernando and Furtado, 1963, p. 156.

Procamallanus clarius Ali, 1956 (Figure 83)

Host: *Clarias batrachus*.

Localization: stomach.

Distribution: India, Singapore.

147

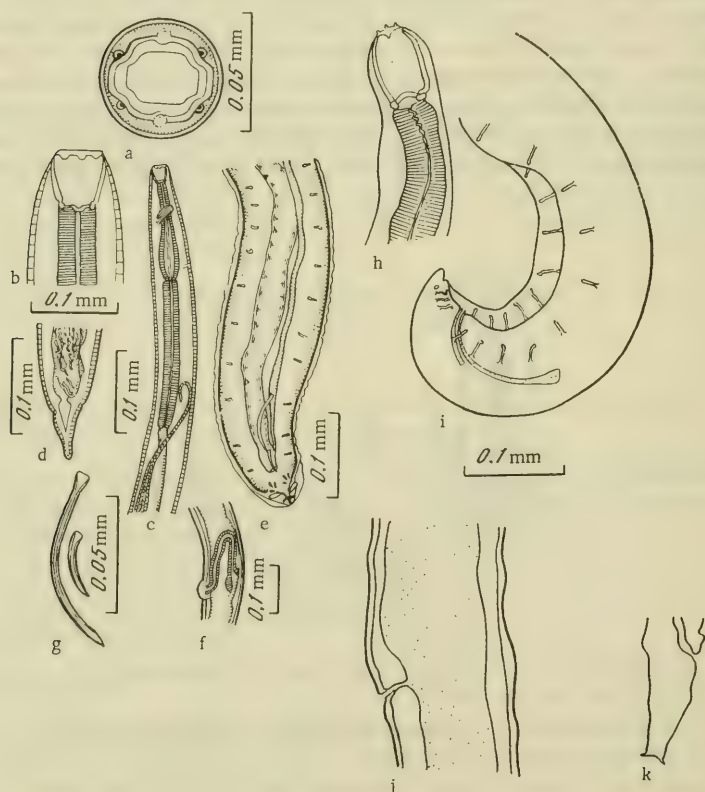


FIGURE 83. *Procamallanus clarius* Ali, 1956:

a — cephalic end, apical; b — same, lateral; c — anterior end of female, lateral; d — caudal end of female, lateral; e — caudal end of male, ventral; f — region of vulva, lateral; g — spicules, ventral; h — cephalic end, lateral; i — caudal end of male, lateral; j — region of vulva, lateral; k — caudal end of female, lateral (a — g — after Ali, 1956; h — k — after Fernando and Furtado, 1963b).

Historical review

Procamallanus clarius was described from *Clarias batrachus* from India. The species was recorded by Fernando and Furtado (1963a) from the same host in Singapore; their material agrees with the description of Ali but their specimens are slightly larger.

Description (after Ali, 1956). Live nematodes reddish. Females thicker and longer than males. Cuticle finely transversely striated with intervals of 0.007 mm. The body narrows in the region of the esophagus in both sexes; cephalic end truncate. Tail short, conical. Buccal capsule without spiral thickening. Two pairs of submedian cephalic papillae and a pair of amphids.

Male. Length 2.44–3.13 mm, maximum width 0.089–0.093 mm. Width of cephalic end 0.043–0.045 mm. Excretory pore situated 0.21–0.26 mm from cephalic end. Buccal capsule in the form of a vase, 0.053–0.055 mm long and 0.055–0.058 mm wide. Nerve ring situated 0.12–0.16 mm from cephalic end, surrounding the muscular part of the esophagus. Muscular anterior part of esophagus 0.23–0.28 mm long, glandular posterior part 0.32–0.38 mm long. Length of esophagus $1/4$ of length of body.

One threadlike testis which extends to the esophagus, where it describes loops and ends in a posteriorly directed part. Vas deferens as wide as the testis; seminal vesicle opening into the cloaca through the short ejaculatory duct. Tail broadly curved, its thin, pointed distal part included in the caudal wings which are very narrow and difficult to see except at the end. Fourteen pairs of caudal papillae, 10 pairs preanal and 4 pairs postanal. The first three pairs of postanal papillae form a group; the last pair is isolated at the end of the tail. Immediately before the last pair of postanal papillae is a pair of transparent cuticular processes which are characteristic for the genus. Spicules thin and weakly chitinated, of similar form but of different length. Right spicule 0.085–0.087 mm long, left spicule 0.029–0.030 mm long. Both spicules are widened in the proximal part and pointed in the distal part. Tail 0.046–0.047 mm long, about $1/60$ of length of body.

Female. Length 5.69–6.02 mm, width 0.133–0.149 mm. Width of cephalic end 0.074–0.080 mm. Excretory pore situated 0.330–0.336 mm from the cephalic end. Buccal capsule 0.058–0.065 mm long and 0.065–0.073 mm wide. Posterior end narrowing a short distance before the anus, end of tail blunt. Vulva with protruding lips, situated between third and last quarter of body, 1.67 mm from end of tail. Vagina 0.35 mm long, directed posteriorly and then turning anteriorly. Two branches of uterus, the posterior branch ending blind, the anterior branch passing into the ovary through the narrow oviduct. Ovary reaching glandular part of esophagus, but its terminal part is directed posteriorly. Seminal vesicle with an inflated part at the connection between oviduct and uterus. Tail 0.037 mm long, i. e. about $1/150$ of length of body. Viviparous.

Description (after Fernando and Furtado, 1963). Females longer and thicker than males. Buccal capsule barrel-shaped, weakly sclerotized, without thickenings. Pharynx opening into the straight muscular part of the esophagus, which is followed by the straight glandular part.

Male. Length 4.24 mm, width 0.096 mm (one specimen). Length of buccal capsule 0.047 mm, width 0.040 mm. Length of pharynx 0.011 mm, width 0.025 mm. Length of muscular part of esophagus 0.360 mm, width 0.054 mm; length of glandular part 0.576 mm, width 0.054 mm. Nerve ring surrounding muscular part of esophagus 0.126 mm from its anterior end or 0.180 mm from the cephalic end.

Tail conical, curved ventrally, with pointed end. Cloaca situated 0.047 mm 149 from end of tail. Ten pairs of preanal and 4 pairs of postanal papillae, one pair at the anus. Spicules of different length, straight, one spicule three times as long as the other; length 0.123 and 0.043 mm, respectively.

Female. Length 5.6–6.1 mm, width 0.144–0.176 mm (two specimens). Buccal capsule 0.076–0.080 mm long and 0.058–0.062 mm wide. Length of pharynx 0.010 mm, width 0.036 mm. Length of muscular part of esophagus 0.370–0.400 mm, width 0.080 mm; length of glandular part of esophagus 0.560–0.610 mm, width 0.064–0.080 mm. Nerve ring surrounding muscular part of esophagus 0.090–0.108 mm from its anterior end or 0.180–0.208 mm from the cephalic end. Tail conical, ending in two finger-shaped processes. Anus situated 0.108–0.140 mm from end of tail. Vulva situated behind middle of body, dividing the body at the ratio of 1.2:1–1.4:1. Viviparous.

References: Ali, 1956, pp. 6–8; Fernando and Furtado, 1963a, pp. 64–65.

Procamallanus confusus Fernando and Furtado, 1963
(Figure 84)

Host: *Heteropneustes fossilis*.

Localization: intestine.

Distribution: Ceylon.

Description (after Fernando and Furtado, 1963b).

Male. Length 3.15–5.0 mm, width 0.045–0.085 mm. Length of muscular part of esophagus 0.235 mm, width 0.039 mm; length of glandular part 0.270 mm, width 0.030 mm. Nerve ring situated 0.114 mm from the cephalic end, 0.066 mm from anterior end of esophagus. Tail strongly curved ventrally; caudal wings weakly developed. Eight pairs of preanal and 8 pairs of postanal papillae. Two pairs of papillae situated around the cloaca. Spicules of different length and form. The smaller left spicule is wide and slipper-shaped, 0.045 mm long and 0.009 mm wide; right spicule sometimes thickened, 0.255 mm long.

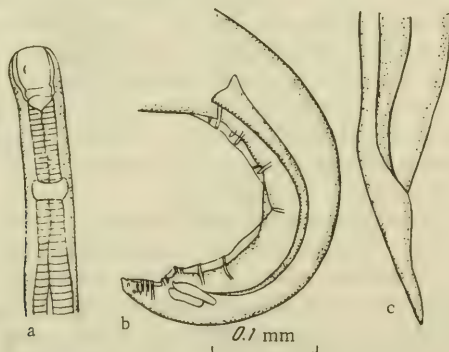


FIGURE 84. *Procamallanus confusus* Fernando and Furtado, 1963:

a — anterior end; b — caudal end of male, lateral; c — caudal end of female, lateral (after Fernando and Furtado, 1963b).

150 Female. Length 4.2–4.8 mm, width 0.085 mm. Length of buccal capsule 0.06 mm, width 0.045 mm. Muscular part of esophagus 0.270–0.300 mm long, 0.045 mm wide; glandular part 0.330–0.375 mm long, 0.030 mm wide. Nerve ring situated 0.150 mm from cephalic end, 0.090 mm from anterior end of esophagus. Vulva situated behind middle of body, dividing the body at the ratio of 1.2:1. Tail conical, 0.150 mm long.

Reference: Fernando and Furtado, 1963, pp.153–156.

Procamallanus daccai Gupta, 1959 (Figure 85)

Host: catfish (species not determined).

Localization: small intestine.

Distribution: East Pakistan.

Description (after Gupta, 1959). Cuticle more strongly striated in females than in males. Mouth surrounded by 2 lateral and 4 submedian papillae. The yellowish brown buccal capsule has a smooth lining, without ribs or leaflike processes, barrel-shaped. Basal ring of buccal apparatus
151 represented by two club-shaped structures; lower part of wall of buccal capsule thicker than upper anterior part, the posterior margin strongly thickened and forming a rim which is connected with the anterior end of the esophagus.

(150)

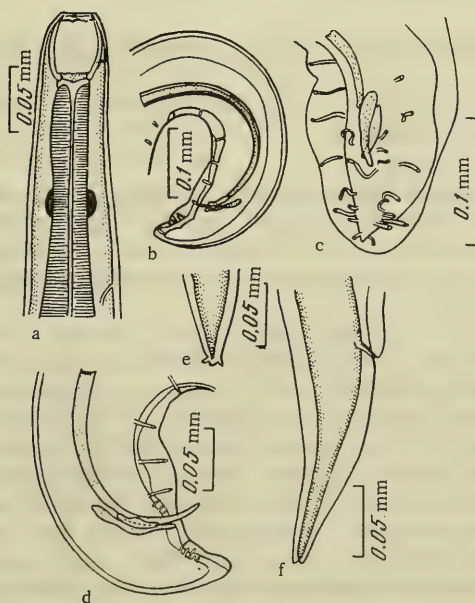


FIGURE 85. *Procamallanus daccai* Gupta, 1959:

a — anterior end, lateral; b, d — caudal end of male, lateral; c — same, ventral;
e — end of tail of female; f — caudal end of female, lateral (after Gupta, 1959).

Male. Length 3.55–4.5 mm, width 0.1–0.125 mm. Striation of cuticle with intervals of 0.013–0.016 mm. Dorsoventral width of cephalic end 0.035–0.045 mm. Esophagus divided into a club-shaped muscular anterior part 0.325–0.625 mm long, 0.042–0.05 mm wide. Nerve ring situated 0.125–0.13 mm, excretory pore 0.18–0.22 mm from cephalic end.

Tail curved ventrally, with rounded end. Tail 0.05–0.07 mm long. Caudal wings well developed. Seven or 8 pairs of long preanal papillae, one pair of adanal papillae, and 9 pairs of postanal papillae; all papillae pedunculate. Three postanal pairs are very small and are situated sub-ventrally at the sides of the cloaca, one behind the other, then follow five pairs of postanal papillae grouped together, and the small posterior pair is isolated. Preanal papillae equally spaced, adanal pair situated laterally at the cloaca. Right spicule with wide proximal end, narrow and pointed at the distal end, 0.36–0.48 mm long. Left spicule absent. Gubernaculum 0.06–0.07 mm long.

Female. Length 4.76–7.39 mm, width 0.12–0.13 mm. Striation of cuticle with intervals of 0.01–0.02 mm. Esophagus divided into a club-shaped muscular anterior part 0.26–0.35 mm long, 0.03–0.04 mm wide. Nerve ring situated 0.12–0.13 mm, excretory pore 0.204–0.26 mm from cephalic end.

Tail with rounded end, with two spinelike processes at the end. Tail 0.12–0.18 mm long. Vulva situated behind middle of body, 2.6–3.96 mm from cephalic end. Uterus distended by larvae. Eggs in uterus at various stages of development.

Reference: Gupta, 1959, pp. 775–778.

Procamallanus devendri Sinha and Sahay 1966 (Figure 86)

Host: *Heteropneustes fossilis*.

Localization: stomach.

Distribution: India.

Description (after Sinha and Sahay, 1966). Small nematodes, blood-red in life. Cuticle coarsely striated. Buccal capsule chitinized, without teeth, tridents, rods, papillae, or spiral striation. Esophagus divided into a club-shaped muscular anterior part and a longer glandular part; ratio of length of the two parts 1:1.3.

Male. Length 3.2–3.5 mm, width 0.05–0.08 mm. Length of buccal capsule 0.032–0.036 mm, width 0.028–0.038 mm. Nerve ring situated 0.074–0.076 mm from cephalic end. Esophagus divided into a muscular part 0.144–0.158 mm long and a glandular part 0.21–0.24 mm long. Tail 152 conical, curved ventrally, with caudal wings, 0.03–0.04 mm long. Thirteen pairs of pedunculate caudal papillae, eight pairs preanal and five pairs postanal. A winglike process situated between the third and fourth pair of postanal papillae on each side. The papillae of the fifth, last, pair are situated one on each side at the end of the tail. Only right spicule present, whip-shaped, with wide proximal end, tapering distally, 0.288–0.3 mm long. Gubernaculum strongly chitinized, 0.02–0.024 mm wide in the middle, maximum width 0.024–0.028 mm, minimum width 0.01–0.014 mm.

Female. Length 6.4–6.8 mm, width 0.13–0.14 mm. Length of buccal capsule 0.048–0.05 mm, width 0.03–0.032 mm. Nerve ring situated 0.062 mm from cephalic end. Esophagus divided into a muscular part

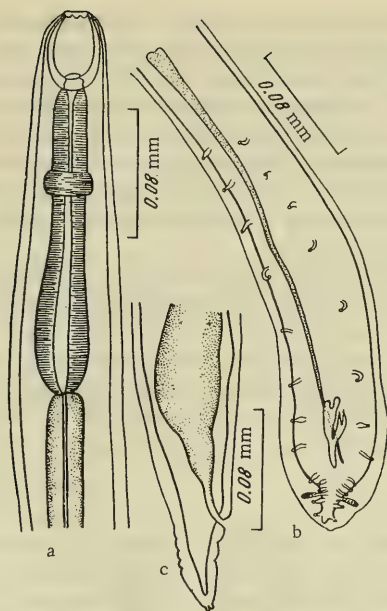


FIGURE 86. *Procammallanus devendri* Sinha and Sahay, 1966:

a — anterior end of female; b — caudal end of male, ventral; c — caudal end of female, lateral (after Sinha and Sahay, 1966).

0.2—0.202 mm long and a glandular part 0.27—0.274 mm long. Tail conical, without papillae, with two short processes at the end. Tail 0.08—0.082 mm long. Vulva situated behind middle of body, 3.47—3.62 mm from cephalic end, with protruding lips. The vagina extends far posteriorly. Uterus with two opposite branches. Viviparous.

Reference: Sinha and Sahay, 1966, pp. 384—388.

Procammallanus glossogobii (Pearse, 1933) Southwell and Kirschner, 1937 (Figure 87)

Synonym: *Thelazo glossogobii* Pearse, 1933

Host: *Glossogobius giurus*.

Localization: intestine.

Distribution: Thailand.

Historical review

Pearse (1933) found four nematodes in the intestine of *Glossogobius giurus*, for which he established the genus *Thelazo* with the single species *Th. glossogobii* Pearse, 1933. His diagnosis of the genus is as follows: Buccal capsule chitinized, barrel-shaped, without valves or lips. Posterior end of tail twisted. Gubernaculum present. Spicules

153 of different length, caudal wings absent. Vulva situated near the anterior end. Southwell and Kirschner (1937) described *Procamallanus slomei* n. sp. They discussed the genus *Thelazo* and came to the conclusion that the buccal capsule in Pearse's drawing is typical for *Procamallanus* and that the nematode should be placed in that genus. In a revision of the genus *Procamallanus*, Annereaux (1946) concluded that Southwell and Kirschner were wrong. He stated that the presence of a gubernaculum and the absence of caudal wings are sufficient reasons to maintain the genus *Thelazo*.

However, Annereaux did not determine the systematic position of the genus *Thelazo* and his argument is weakened by his statement that the genus *Thelazo* resembles the genus *Procamallanus*.

This is a typical example of the establishment of new systematic units without a detailed study of the forms. The diagnosis of Pearse is too short and does not determine the systematic position of his species. We therefore consider *Thelazo glossogobii* as a species of the genus *Procamallanus*.

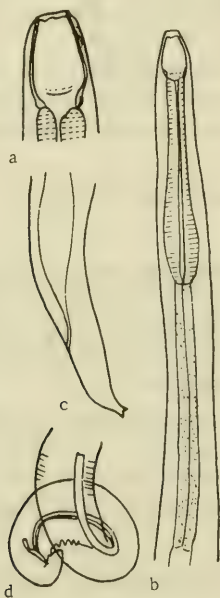


FIGURE 87. *Procamallanus glossogobii* (Pearse, 1933)
Southwell and Kirschner, 1937:

a — cephalic end; b — anterior end; c — caudal end of female,
lateral; d — caudal end of male (after Pearse, 1933).

Description (after Pearse, 1933). Cuticle thin and transparent. Buccal capsule reddish brown, barrel-shaped, its anterior margin thin, thicker posteriorly especially near the base. Muscular part of esophagus slightly widened posteriorly.

Male. Length 2.9 mm, width 0.08 mm. Tail 0.04 mm long, conical, with rounded end. Gubernaculum 0.06 mm long, almost straight. Spicules in the form of a coil, right spicule 0.45 mm long, left spicule 0.17 mm long. Six sessile preanal papillae situated close together. Caudal wings absent.

Female. Length 3.1 mm, width 0.1 mm. Length of buccal capsule 0.07 mm. Muscular part of esophagus 0.275 mm long. Vulva situated at end of anterior part of body. Eggs and larvae in the uterus arranged in a row. Tail 0.13 mm long, conical, ending in two short, divergent spines.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.[?]; Annereaux, 1946, pp.299—303; Pearse, 1933, p.179—191; Southwell and Kirschner, 1937, pp.245—265.

154 *Procamallanus heteropneustus* Ali, 1956 (Figure 88)

Host: *Heteropneustes fossilis*.

Localization: stomach.

Distribution: India.

Description (after Ali, 1956). Body thin, cylindrical, slightly narrower in the region of the esophagus. Cuticle thick, transverse striation with intervals of 0.006 mm. Excretory pore situated slightly behind the connection between the muscular and glandular parts of the esophagus. Nerve ring surrounding muscular part of esophagus near its beginning. Buccal capsule widest in the middle; basal and anterior parts of the same width. Wall of buccal capsule without spiral thickenings, thicker at the base than at the apex. Mouth oval in apical view. Two pairs of submedian cephalic papillae. A pair of lateral amphids. Cephalic end truncate.

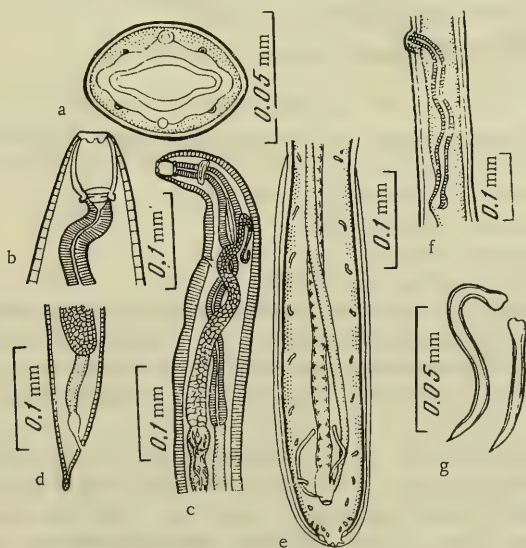


FIGURE 88. *Procamallanus heteropneustus* Ali, 1956:

a — cephalic end, apical; b — same, lateral; c — anterior end of female, lateral; d — caudal end of female, lateral; e — posterior end of male, ventral; f — region of vulva, lateral; g — spicules, ventral (after Ali, 1956).

Male. Length 4.51–4.56 mm, width 0.09–0.10 mm. Dorsoventral width of cephalic end 0.051 mm. Excretory pore situated 0.37 mm, nerve ring 155 0.13 mm from cephalic end. Length of buccal capsule 0.063 mm, width 0.047 mm, anterior and posterior parts 0.029 mm wide. Length of esophagus 0.83 mm, i. e. about $1/5$ of length of body, muscular part 0.27 mm long, glandular part 0.56 mm. The single testis extends to the muscular part of the esophagus. Tail with narrow caudal wings which are contiguous posteriorly. Thirteen pairs of long, riblike caudal papillae, eight pairs preanal and five pairs postanal. The postanal papillae begin immediately behind the cloaca; three pairs are situated close together and the fifth pair at the end of the tail. Between the last two pairs of postanal papillae are two transparent, blunt, rounded processes which are characteristic for the genus. Spicules weakly chitinized, of different length but of similar form, widened proximally and pointed distally; right spicule 0.073 mm long, left spicule 0.043 mm.

Female. Length 6.68–7.70 mm, width 0.130–0.135 mm. Dorsoventral width of cephalic end 0.068 mm. Excretory pore situated 0.46 mm, nerve ring 0.16 mm from cephalic end. Buccal capsule 0.071 mm long, 0.059 mm wide, anterior and posterior parts 0.036 mm wide. Mouth 0.034 mm long and 0.014 mm wide. Esophagus 1.08 mm long, i. e. $1/7$ of length of body; anterior part 0.39 mm long, posterior part 0.69 mm.

Vulva with distinct lips, situated 2.74 mm from the posterior end, dividing the body at the ratio of 3:1. Length of ovejector 0.57 mm. Uteri diverging. One anterior ovary; oviduct narrow. A distinct seminal vesicle present at the connection of the uteri. Ovary sinuous, its end directed anteriorly. In mature females the uteri are filled with larvae about 0.407 mm long and 0.016 mm wide. The genital primordium of the larvae adheres closely to the intestine, situated 0.133 mm from the cephalic end. Tail of females narrowing, with blunt end, 0.038 mm long.

Reference: Ali, 1956, pp. 3–6.

Procamallanus hindenensis Lal, 1965 (Figure 89)

Host: *Heteropneustes fossilis*.

Localization: stomach.

Distribution: India.

Description (after Lal, 1965).

Male. Length 2.7–4.0 mm, width 0.05–0.11 mm. Buccal capsule, 0.053–0.059 mm long and 0.032 mm wide. Length of esophagus 0.493–0.648 mm, muscular anterior part 0.166–0.298 mm long, glandular posterior part 0.255–0.426 mm. Nerve ring situated 0.138–0.170 mm from the cephalic end.

Tail curved ventrally, with rounded end. Caudal wings well developed. Thirteen pairs of pedunculate genital papillae, nine pairs preanal and four pairs postanal. Only the right spicule present, 0.227–0.514 mm long. Gubernaculum bifid anteriorly, pointed posteriorly.

Female. Length 5.1–7.1 mm, width 0.11–0.17 mm. Buccal capsule 0.064 mm long, 0.043–0.059 mm wide. Length of esophagus 0.588–0.916 mm, muscular anterior part 0.268–0.357 mm long, glandular posterior part 0.341–0.639 mm. Nerve ring situated 0.192–0.224 mm from the cephalic end. Tail pointed, bifid, 0.085–0.149 mm long. One ovary. Vulva situated behind middle of body, 3.0–4.7 mm from cephalic end.

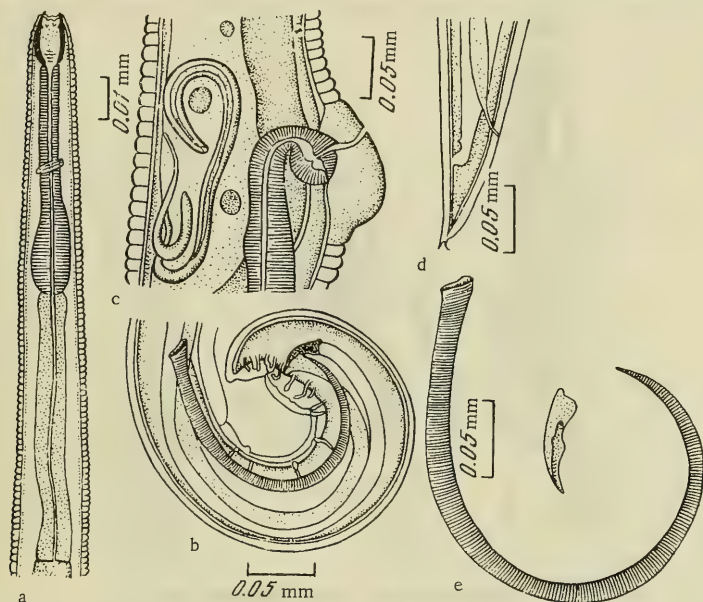


FIGURE 89. *Procammallanus hindenensis* Lal, 1965:

a – anterior end; b – caudal end of male, lateral; c – region of vulva, lateral; d – caudal end of female, lateral; e – spicules (after Lal, 1965).

Reference: Lal, 1965, pp.199–200.

Procammallanus lonis Yamaguti, 1941 (Figure 90)

Host: *Lo unimaculatus*.

Localization: small intestine.

Distribution: Japan.

Description (after Yamaguti, 1941).

Male. Length 13.6–14.75 mm, width 0.32–0.35 mm. Cuticle about 0.012 mm thick, finely transversely striated at the cephalic end. Nerve ring situated 0.3–0.36 mm from cephalic end. Buccal capsule with smooth walls about 0.010 mm thick, 0.110–0.117 mm wide and 0.150–0.165 mm long,

including the basal ring which is 0.060–0.066 mm wide. Muscular anterior part of esophagus 0.55–0.59 mm long and 0.11 mm wide, glandular posterior part 0.85–0.90 mm long and 0.099–0.110 mm wide.

- 157 Tail 0.096–0.105 mm long. Caudal wings connected anteriorly, about 0.45 mm long, supported by 3 long, thin preanal papillae and 6 shorter but similar postanal papillae on each side. Right spicule 0.5 mm long, sometimes sigmoid at the distal end, with narrow wings; left spicule 0.22 mm long, weakly chitinized, with almost straight distal end.

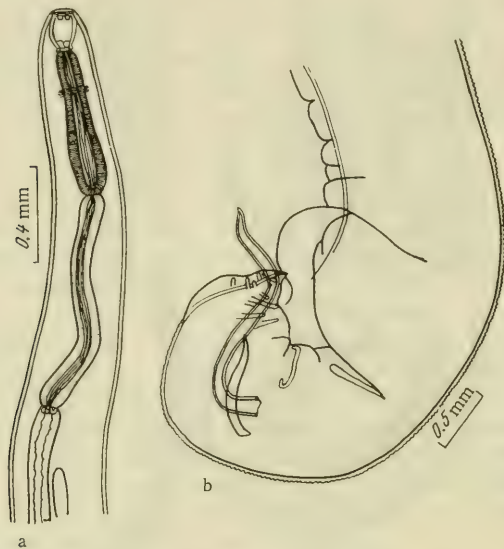


FIGURE 90. *Procammallanus lonis* Yamaguti, 1941:

a — anterior end; b — caudal end of male (after Yamaguti, 1941).

Female. Length 23.8–26.6 mm, body of almost uniform width its entire length, 0.65–0.70 mm wide, except at the ends. Cuticle 0.016 mm thick, transversely striated except at the cephalic end. Nerve ring situated 0.34–0.35 mm from cephalic end. Buccal capsule 0.13–0.15 mm wide, 0.19–0.20 mm long including the basal ring which is 0.075–0.084 mm wide. Wall of basal ring 0.013–0.014 mm thick. Muscular anterior part of esophagus 0.60–0.63 mm long and 0.12–0.14 mm wide, glandular posterior part 0.85–1.1 mm long and 0.11–0.13 mm wide.

Tail blunt-conical, 0.16–0.18 mm long. The uterus extends to the posterior end of the muscular part of the esophagus if it contains embryos, ending 1.0–1.18 mm from end of tail. Vulva situated 8.5 mm from cephalic end, dividing the body at the ratio of 1:1.8–2.23. Larvae 0.52–0.57 mm long and 0.018–0.021 mm wide.

Reference: Yamaguti, 1941, pp. 343–396.

Host: *Clarias batrachus*.

Localization: stomach.

Distribution: India.

Description (after Lal, 1965).

Male. Length 3.36–5.29 mm, width 0.096–0.149 mm. Buccal capsule 0.053–0.075 mm long and 0.043–0.053 mm wide. Length of esophagus 0.658–0.97 mm, muscular anterior part 0.245–0.371 mm long, glandular posterior part 0.413–0.599 mm. Nerve ring situated 0.149–0.213 mm from cephalic end.

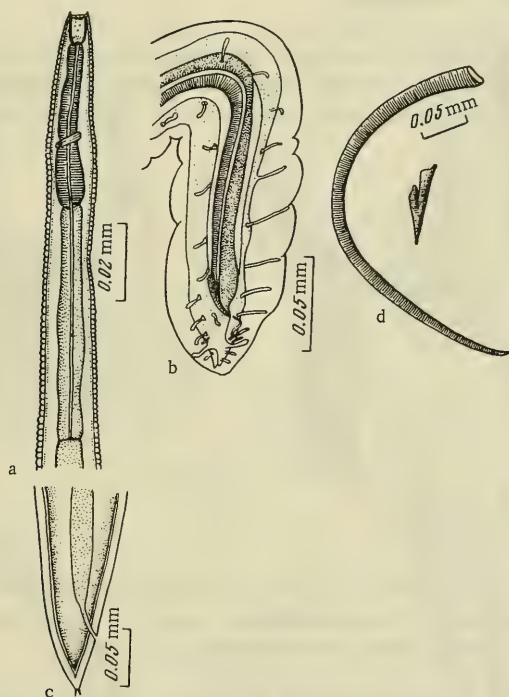


FIGURE 91. *Procamallanus magurii* Lal, 1965:

a — anterior end; b — caudal end of male, ventral; c — caudal end of female, lateral; d — spicules (after Lal, 1965).

Tail curved ventrally, with rounded end. Caudal wings well developed. Fourteen pairs of caudal papillae, nine pairs preanal and five pairs postanal. One spicule, 0.371–0.436 mm long. Gubernaculum bifid anteriorly, pointed posteriorly.

Female. Length 7.14–11.53 mm, width 0.149–0.256 mm. Buccal capsule 0.085–0.107 mm long and 0.048–0.064 mm wide. Length of esophagus 0.85–1.123 mm, muscular anterior part 0.330–0.658 mm long,

159 glandular posterior part 0.511–0.720 mm. Nerve ring situated 0.180–0.213 mm from cephalic end. Tail pointed, distinctly bifid, 0.107–0.170 mm long. One ovary. Vulva situated behind middle of body, 3.427–6.141 mm from cephalic end.

Reference: Lal, 1965, pp.199–200.

Procamallanus malacensis Fernando and Furtado, 1963
(Figure 92)

Host: *Channa lucius*.

Localization: intestine.

Distribution: Indonesia.

Description (after Fernando and Furtado, 1963a). Relatively small nematodes. Female larger than male (one specimen of each sex examined). Buccal capsule weakly sclerotized, pharynx weakly sclerotized, opening into the muscular part of the esophagus; then follows the glandular part.

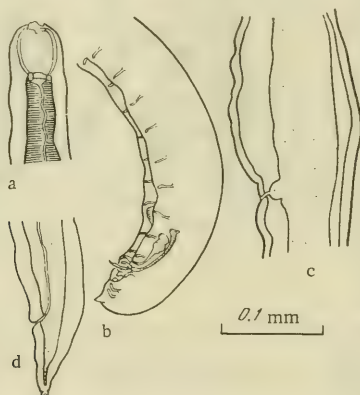


FIGURE 92. *Procamallanus malacensis* Fernando and Furtado, 1963:

a — cephalic end, lateral; b — caudal end of male, lateral; c — region of vulva, lateral;
d — caudal end of female, lateral (after Fernando and Furtado, 1963a).

Male. Length 2.640 mm, width 0.096 mm. Buccal capsule 0.040 mm long, 0.033 mm wide. Length of pharynx 0.015 mm, width 0.026 mm. Length of glandular esophagus 0.449 mm, width 0.032 mm. Nerve ring surrounding muscular part of esophagus 0.130 mm from its anterior end or 0.174 mm from the cephalic end.

Tail conical, curved ventrally, with pointed end. Cloaca situated 0.040 mm from end of tail. Nine pairs of preanal and 2 pairs of postanal papillae, one pair just before the cloaca and one pair behind the anus. Spicules weakly sclerotized, of different length: larger spicule 0.130 mm long, smaller, thicker spicule 0.050 mm, width 0.075 mm.

Female. Length 4.494 mm, width 0.150 mm. Buccal capsule 0.056 mm long and 0.045 mm wide. Length of pharynx 0.019 mm, width 0.037 mm.

160 Muscular esophagus 0.352 mm long, 0.048 mm wide; length of glandular esophagus 0.528 mm, width 0.040 mm. Nerve ring surrounding muscular

part of esophagus 0.133 mm from its anterior end or 0.207 mm from the cephalic end. Tail conical, ending in three finger-shaped processes. Anus situated 0.089 mm from end of tail. Vulva situated just behind middle of body, dividing the body at the ratio of 1.25:1.

Reference: Fernando and Furtado, 1963, pp. 65–67.

Procamallanus mathurai Pande, Bhatia, and Rai, 1963
(Figures 93, 94)

Host: *Heteropneustes fossilis*.

Localization: stomach.

Distribution: India.

(161)

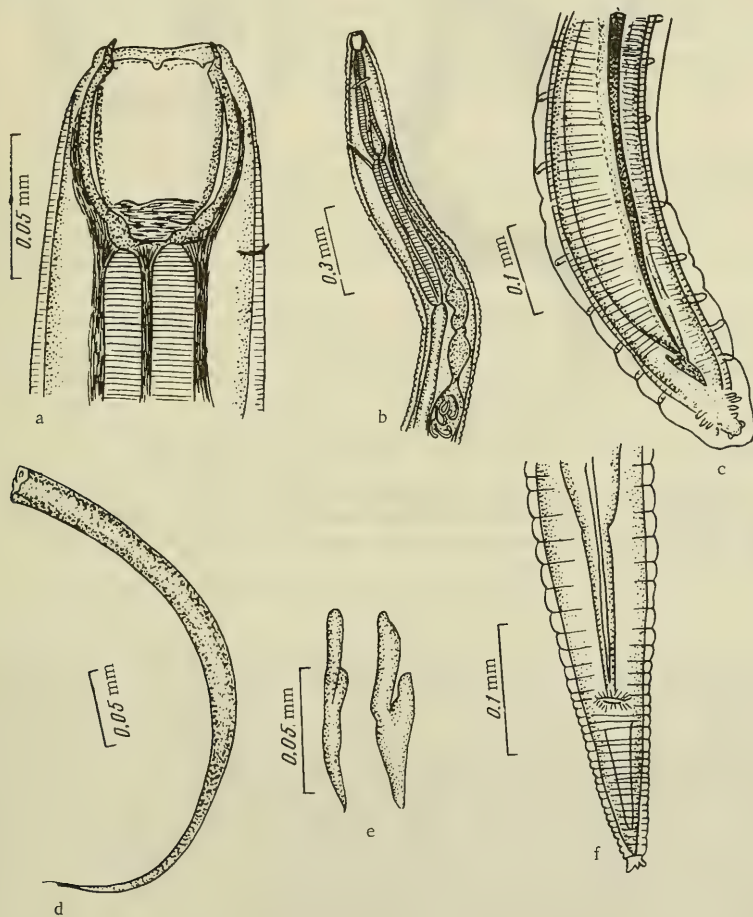


FIGURE 93. *Procamallanus mathurai* Pande, Bhatia, and Rai, 1963:

a — cephalic end; b — anterior end of adult female, lateral; c — caudal end of male, dorsoventral; d — right spicule; e — gubernaculum, different aspects; f — caudal end of female, ventral (after Pande, Bhatia, and Rai, 1963b).

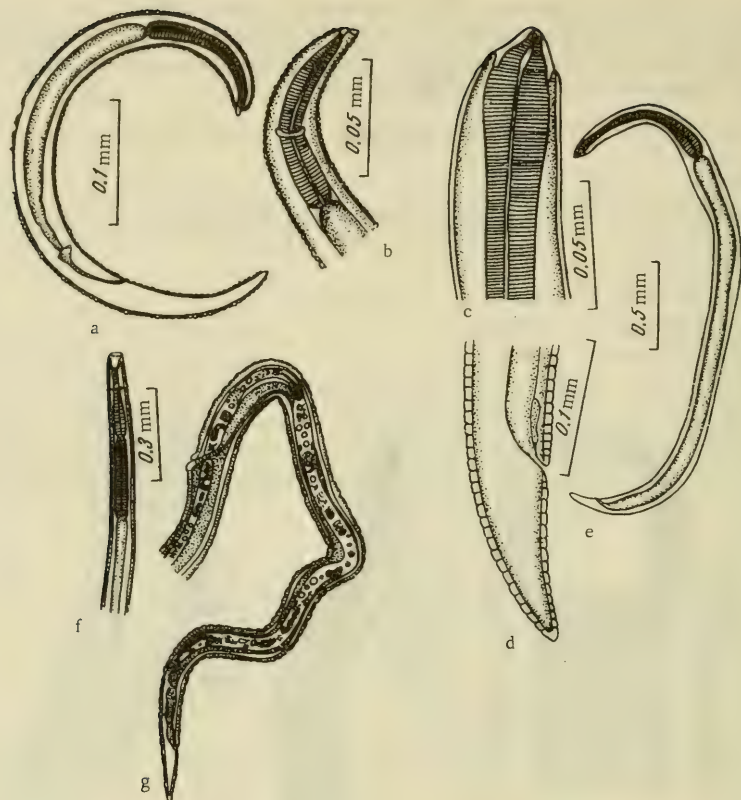


FIGURE 94. *Procammallanus mathurai* Pande, Bhatia, and Rai, 1963:

a — first-stage larva, general view; b — anterior end of first-stage larva; c — cephalic end of third-stage larva; d — caudal end of third-stage larva, lateral; e — third-stage larva, general view; f — anterior end of fourth-stage larva; g — posterior part of body of young female (after Pande, Bhatia, and Rai, 1963b).

Description (after Pande, Bhatia, and Rai, 1963b). Light pink nematodes, with finely striated, thick cuticle. Cephalic end truncate, with 4 submedian cephalic papillae on the lower margin of the weakly chitinated rim and with a pair of lateral amphids. Buccal capsule barrel-shaped, with smooth, yellowish brown, chitinated wall. Esophagus consisting of two distinct parts. Tail with markedly projecting lateral processes at the end.

Male. Length 3.2–4.1 mm, width 0.092–0.11 mm. Tail curved ventrally. Buccal capsule 0.048–0.051 mm long and 0.032–0.038 mm wide. Length of esophagus 0.49–0.62 mm, muscular anterior part 0.23–0.29 mm long, glandular posterior part 0.26–0.33 mm. Nerve ring situated 0.12–0.13 mm, excretory pore 0.24–0.27 mm from the cephalic end.

Tail with narrow caudal wings, with 12 pairs of long, riblike papillae. The eight anterior pairs are widely spaced. Seven pairs of preanal papillae,

one pair of adanal papillae, and a group of 4 postanal pairs, the second pair the longest. Only the right spicule present, 0.25–0.27 mm long, its distal end markedly thinner. Gubernaculum slightly Y-shaped, the two proximal parts of different length: longer part 0.036–0.04 mm long, shorter part 0.044–0.05 mm.

Female. Length 5.0–7.8 mm, width 0.13–0.15 mm. Buccal capsule 0.054–0.064 mm long and 0.04 mm wide. Length of esophagus 0.67–0.88 mm, muscular anterior part 0.3–0.4 mm long, glandular posterior part 0.37–0.48 mm. Nerve ring situated 0.15–0.16 mm, excretory pore 0.2–0.29 mm from the cephalic end. Vulva situated behind middle of body, 2.46–3.52 mm from end of tail which is 0.09–0.112 mm long.

First-stage larva taken from a female 0.5–0.54 mm long and 0.026–0.028 mm wide. Cuticle transversely striated. A spinelike process situated laterally at the cephalic end. Buccal capsule rudimentary, 0.0043 mm wide. Length of esophagus 0.08–0.084 mm; Nerve ring situated 0.043 mm from the cephalic end. Anus situated 0.2–0.25 mm from end of tail.

Third-stage larva 3.08 mm long. Cephalic end conical, buccal capsule rudimentary, esophagus simple, club-shaped, 0.1 mm long. Tail 0.01 mm long.

161 Fourth-stage larva (female). Length 3.7 mm, width 0.8 mm. Buccal capsule 0.044 mm long and 0.044 mm wide. Length of esophagus 0.49 mm. Nerve ring situated 0.12 mm, excretory pore 0.17 mm from the cephalic end.

Vulva situated 1.42 mm from end of tail. Vagina muscular, 0.56 mm long. Tail 0.045 mm long.

162 Fifth-stage larva (female). Length 5.135 mm, width 0.086 mm. Buccal capsule 0.056 mm long and 0.052 mm wide. Length of esophagus 0.62 mm, muscular anterior part 0.27 mm long, glandular posterior part 0.35 mm. Nerve ring situated 0.14 mm, excretory pore 0.3 mm from the cephalic end. Vulva situated 2.185 mm from end of tail; uterus with a few eggs. Tail 0.05 mm long.

Reference: Pande, Bhatia, and Rai, 1963b, pp.105–118.

Procamallanus mehrii Agarwal, 1930 (Figure 95)

Host: *Wallago attu*.

Localization: mainly posterior part of body cavity; one specimen found in the swim bladder.

163 Distribution: India.

Description (after Baylis, 1939). Cuticular striation with intervals of 0.0036 mm. Buccal capsule of different form in the two sexes. In the male it is cuplike; in the female it is more oblong and barrel-shaped. Its walls without spiral thickenings. At the anterior end of the buccal cavity there are 4 chitinized platelike structures, the two median structures markedly larger. They are weakly separated and covered laterally with groups of filaments which are processes of the wall of the capsule. Together with those of the median plates, there are 9–10 filaments in the male and 12 in the female; nearer to the outer plates there are 6–7 filaments in the male and 10 in the female. Their form is also different in the two sexes: they are more or less conical in the male, oblong and more or less spindle-shaped in the female (Agarwal, 1930).

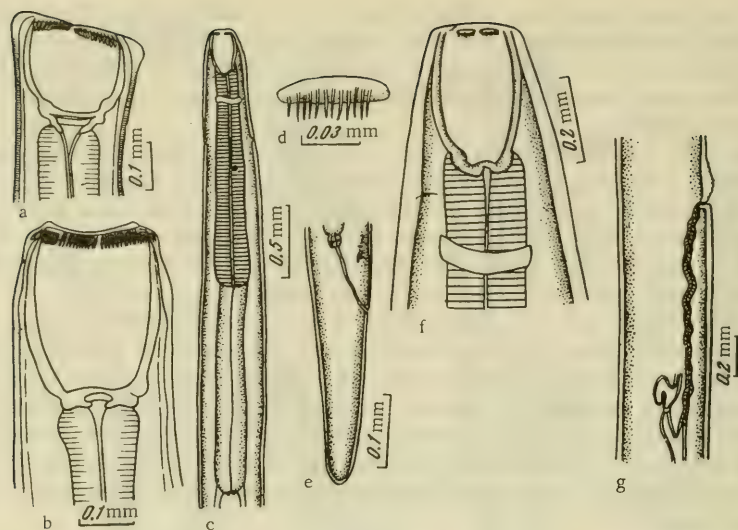


FIGURE 95. *Procammallanus mehrii* Agarwal, 1930:

a — cephalic end of male; b — cephalic end of female; c — anterior end of female, lateral; d — chitinous plate with 12 leaflike processes; e — caudal end of female, lateral; f — cephalic end; g — region of vulva, lateral (a, b — after Agarwal, 1930; c — g — after Khera, 1955).

Male. Length 16–19 mm, width 0.32–0.36 mm. Depth and width of buccal capsule 0.17 mm. Anterior part of esophagus 0.92–1.14 mm long, posterior part 0.8–1.2 mm. Nerve ring situated about 0.27–0.32 mm, excretory pore 0.48–0.5 mm from the cephalic end.

Tail about 0.1 mm long. Caudal wings 0.94–1.2 mm long. Spicules of the same length, 0.285 mm.

Female. Length 33 mm, width 0.425 mm. Length of buccal capsule 0.35 mm, width 0.2 mm. Anterior part of esophagus 1.61 mm long, posterior part 1.41 mm. Nerve ring situated 0.53 mm, excretory pore 0.96 mm from the cephalic end.

Tail 0.23 mm long. Vulva situated about 10 mm from posterior end. The cuticle is thickened near the vulva and forms a "slitlike" swelling ventrally in front of the vulva and a larger swelling on the dorsal surface of the body.

Description (after Khera, 1955).

Male not described.

Female. Length 40 mm, width 0.51 mm. Cuticle striated with intervals of 0.0035–0.006 mm. Buccal capsule chitinized, barrel-shaped, 0.355 mm long and 0.2 mm wide; its walls without spiral thickenings. At the anterior end of the buccal capsule are 4 chitinized platelike formations of equal size with 12 leaflike processes. Esophagus divided into a club-shaped muscular anterior part which is longer than the cylindrical glandular posterior part. Length of muscular part 1.71 mm, of glandular part 1.5 mm. Intestine wide, with large lumen. Rectum short and narrow, 0.12 mm long. Three large glandular cells at the connection between intestine and rectum. Nerve ring and cervical papillae situated at the level of the anterior part of the

esophagus, 0.54 and 0.93 mm, respectively, from the cephalic end. Cervical papillae large and projecting. Excretory pore situated 1.2 mm from the cephalic end.

Tail finger-shaped, 0.238 mm long. Vulva situated in posterior half of body, 14.8 mm from end of tail. Cuticle thickened ventrally just before the vulva. The large thickening on the dorsal surface described by Agarwal (1930) is absent. Vagina muscular, curved, then extending straight posteriorly for 1.4 mm. Common duct of uterus short, dividing into two branches, one extending anteriorly, the other posteriorly. The anterior branch of the uterus ends in an ovary, 2.1 mm before the posterior end of the esophagus. Posterior branch of uterus ending blind, 1.5 mm before the anus.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 33; Agarwal, 1930, pp. 59—64; Baylis, 1939, pp. 218—219; Khera, 1955, pp. 243—244.

Procamallanus muelleri Agrawal, 1966 (Figure 96)

Host: *Heteropneustes fossilis*.

Localization: stomach.

Distribution: India.

Description (after Agrawal, 1966b). Males and females of slightly different size. Mouth surrounded by 2 lateral and 4 submedian papillae. Buccal capsule barrel-shaped, smooth, without crests or groups of leaves. Basal part of capsule thickened, forming a circular connection with the esophagus. Cuticle more strongly striated in females than in males. Intervals of striation 0.012—0.015 mm in males and 0.015—0.018 mm in females.

165 Male. Length 4.64 mm, width 0.11 mm. Width of head 0.05 mm. Buccal capsule 0.07 mm long and 0.04 mm wide. Esophagus divided into a club-shaped muscular anterior part 0.27 mm long and 0.04 mm wide and a glandular posterior part 0.24 mm long and 0.03 mm wide. Length of esophagus 0.51 mm. Nerve ring situated 0.12 mm, excretory pore 0.18 mm from the cephalic end. Tail with rounded end, 0.13—0.22 mm long.

Caudal end curved ventrally, with one spiral coil. Caudal wings well developed, extending to end of tail, 0.35—0.51 mm long. Fourteen to 18 pairs of anal papillae, eight or nine pairs preanal, one pair adanal, and five to seven pairs postanal. The preanal papillae are pedunculate, almost equally spaced. The single pair of pedunculate adanal papillae is situated near the anus. Two pairs of small sessile papillae surround the anus; 3 to 5 pairs of the postanal papillae are long, pedunculate, grouped together; the papillae of the posterior pair are small, sessile, isolated. Phasmids present at end 166 of tail. Spicules tubular, of the same length and similar in form, 1.40—1.41 mm long, widening at the anterior end and tapering posteriorly. Gubernaculum absent.

Female. Length 3.56—6.54 mm, width 0.11—0.17 mm. Width of head 0.05—0.06 mm. Buccal capsule 0.057—0.07 mm long, 0.04—0.05 mm wide. Length of muscular anterior part of esophagus 0.28—0.31 mm, width 0.04—0.06 mm, glandular posterior part 0.31—0.39 mm long, 0.05—0.07 mm wide. Length of esophagus 0.59—0.69 mm. Nerve ring situated 0.13—0.16 mm, excretory pore 0.17—0.21 from the cephalic end. Tail short,

rounded, ending in two small spinelike processes; tail 0.10–0.15 mm long. Vulva situated behind middle of body, 1.98–3.61 mm from the cephalic end. Uterus filled with larvae and eggs.

(165)

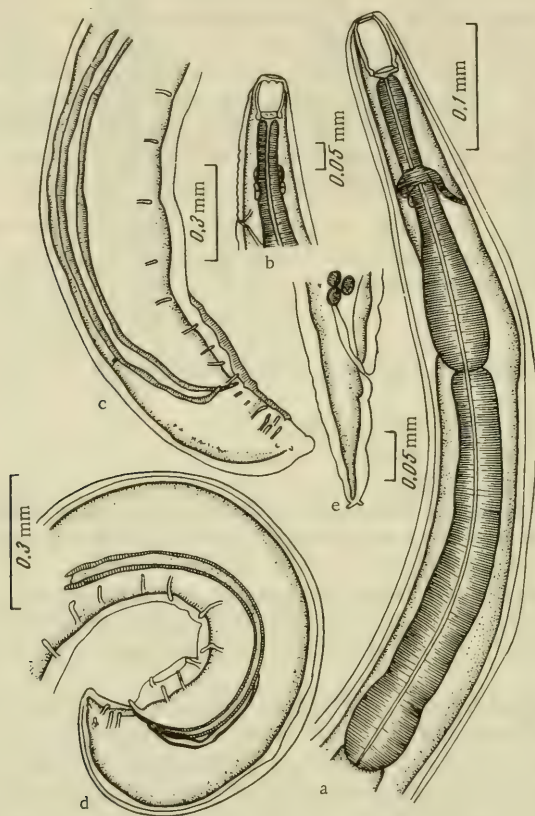


FIGURE 96. *Procammallanus muelleri* Agrawal, 1966:

a, b — anterior end, lateral; c, d — caudal end of male, lateral; e — caudal end of female, lateral (after Agrawal, 1966b).

Reference: Agrawal, 1966b, pp. 204–208.

Procammallanus planoratus Kulkarni, 1935 (Figure 97)

Host: *Clarias batrachus*.

Localization: intestine.

Distribution: India.

Description (after Kulkarni, 1935). Cephalic end narrowing, rounded. Cuticle smooth, without striation. Buccal capsule 0.082 mm long and 0.061 mm wide, with a smooth, chitinized lining without leaves or crests. Two club-shaped structures at the base of the buccal capsule. Length of esophagus 0.41 mm. Nerve ring situated 0.24 mm, excretory pore 0.31 mm from the cephalic end.

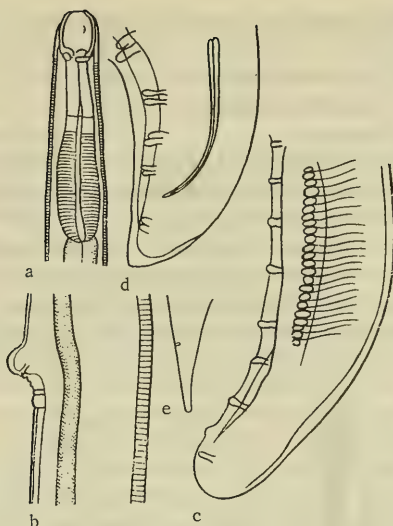


FIGURE 97. *Procammallanus planoratus* Kulkarni, 1935:

a — anterior end; b — region of vulva, lateral; c, d — caudal end of male, lateral;
e — caudal end of female (after Kulkarni, 1935).

Male. Length 3.85 mm, width 0.061 mm. Tail slightly curved ventrally, with bluntly pointed end. Caudal wings well developed. Seven pairs of preanal and one pair of postanal pedunculate papillae. The stalks of the preanal papillae are longer than those of the postanal papillae. Spicules of the same length, 0.12 mm. Gubernaculum absent.

Female. Length 5.07–7.26 mm, width 0.079 mm. Tail bluntly pointed, 0.11 mm long. Vulva situated in about middle of body, 1.4–3.38 mm before the caudal end. A distinct lobelike structure forms the anterior lip of the vulva. Vagina directed posteriorly.

Description (after Baylis, 1939). Cuticle without striation. Buccal capsule 0.082 mm long and 0.061 mm wide, without crests or leaves. Basal ring of buccal apparatus represented by two chitinoid formations of spine-like form. Esophagus, measured from the cephalic end, 0.41 mm long. Nerve ring situated 0.24 mm, excretory pore 0.31 mm from cephalic end.

Male. Length 3.85 mm, maximum width 0.061 mm. Caudal end moderately curved ventrally with rounded end. Eight pairs of pedunculate papillae, seven pairs preanal and one pair postanal. Spicules of the same length, 0.12 mm.

Female. Length 5.0–7.3 mm, maximum width 0.079 mm. Vulva situated 1.4–3.38 mm from end of tail. Its anterior lip forms a projecting lobe. Tail 0.11 mm, long with blunt end.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 33; Baylis, 1939, pp. 219–220; Kulkarni, 1935, pp. 29–32; Yamaguti, 1961a, p. 45.

Procamallanus sigani Yamaguti, 1935 (Figure 98)

Host: *Siganus fuscescens*.

Localization: small intestine.

Distribution: Japan.

Description (after Yamaguti, 1935). Cuticle 0.006 mm thick, finely transversely striated. Buccal capsule with smooth outer and inner surface, with a distinct cuticular ring at the base.

Male. Length 10–14 mm. Length of buccal capsule 0.093–0.105 mm, width 0.030–0.114 mm. Nerve ring situated 0.22–0.26 mm from cephalic end. Muscular anterior part of esophagus 0.32–0.41 mm long, 0.07–0.08 mm wide; glandular posterior part 0.58–0.68 mm long, 0.066–0.088 mm wide.

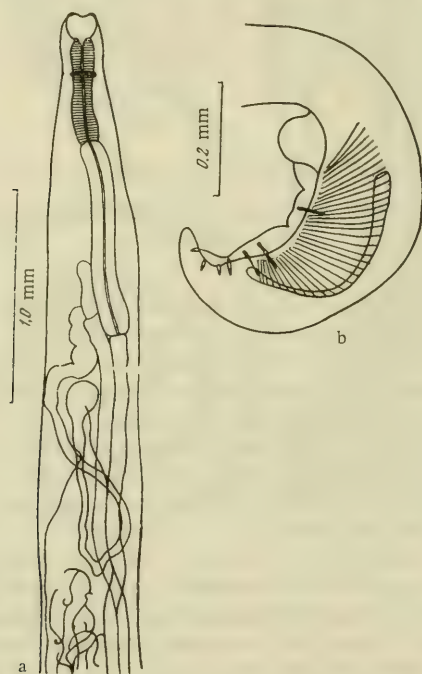


FIGURE 98. *Procamallanus sigani* Yamaguti, 1935:

a — anterior end of female, lateral; b — posterior end of male, lateral
(after Yamaguti, 1935).

Testis beginning 1.8–2.7 mm from the cephalic end, widening posteriorly until it narrows abruptly at the connection with the relatively short, curved vas deferens. Seminal vesicle about 4 mm long, markedly narrower at both 168 ends. The small ejaculatory duct is lined with high cylindrical epithelium, about 1.5 mm long. The long spicule is distinctly curved, about 0.4 mm long. Short spicule 0.12–0.15 mm long. Caudal wings connected anteriorly and supported on each side by 3 long, thin preanal and 3 shorter postanal papillae. Behind the anus are 3 further outer papillae on each side: one inside and two

outside the caudal wings. Many subcuticular muscle fibers present in the preanal region of the caudal wings. Tail 0.15–0.20 mm long.

Female. Length 19–27 mm, maximum width 0.55 mm. Length of buccal capsule 0.11–0.12 mm, width 0.11–0.138 mm. Nerve ring situated 0.28–0.33 from cephalic end.

Muscular anterior part of esophagus 0.40–0.51 mm long and 0.100–0.135 mm wide, glandular posterior part 0.63–0.91 mm long and 0.11–0.13 mm wide. The anterior end of the ovary is situated at different levels in different specimens. In a mature specimen 21.5 mm long it is situated 1.34 mm behind the vulva, in others at the same level or anterior to it. In a specimen 26 mm long it is situated 4.1 mm from the cephalic end. Oviduct forming a figure 8. The simple, tubular uterus begins 1.4–2.4 mm from the cephalic end and ends 0.75–2.8 mm from the posterior end in a vermiform appendage which is directed posteriorly or anteriorly. Vagina muscular, 0.75–1.2 mm long, straight, sometimes curved in the proximal part. Vulva situated 7.3–11.3 mm from the cephalic end, dividing the body at the ratio of 1:1.3–1.75; its anterior lip about 0.060 mm long with a thin cuticular membrane, the teatlike posterior lip is 0.018 mm long and 0.030 mm wide. Fully developed larvae in the uterus with a thin tail, 0.52 mm long and 0.015 mm wide. Length of tail of female 0.30–0.38 mm, with pointed end.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.34; Yamaguti, 1935, pp.378–380; 1961b, p.45.

Procamallanus slomei Southwell and Kirschner, 1937
(Figure 99)

Host: *Xenopus laevis*.

Localization: stomach.

Distribution: Africa.

Description (after Southwell and Kirschner, 1937).

Male. Length 1.8–2 mm, width 0.09–0.15 mm. Cuticle less strongly striated than in the female. Excretory pore situated in the region of the nerve ring. Mouth with 6 papillae: two lateral and four median. The brownish yellow, barrel-shaped buccal capsule has a hexagonal anterior opening; it is 0.087–0.097 mm long and 0.065–0.075 mm wide. Inner surface of buccal capsule smooth. Esophagus divided into a muscular anterior part, swollen posteriorly, 0.2–0.24 mm long; glandular posterior part 0.22–0.29 mm long. Nerve ring surrounding muscular part of esophagus between its anterior and middle third. Testis forming a long, thin, sinuous tube situated in the region of the glandular esophagus. It passes into the long, wide vas deferens, the anterior end of which is widened and forms the seminal vesicle. The vas deferens then narrows and passes into the ejaculatory duct. Only one spicule, 0.087–0.1 mm long. Caudal wings present. Twelve pairs of caudal papillae: eight pairs preanal, one pair adanal and three pairs postanal. All papillae pedunculate. Tail curved ventrally, with rounded end, 0.06 mm long.

Female. Length 2.5–2.9 mm, width 0.22 mm. Buccal capsule 0.135 mm long and 0.097 mm wide. Muscular part of esophagus 0.26 mm long, glandular part 0.29 mm. Vulva situated before middle of body. Tail with rounded end

and with a crown of 8–10 spines. Ovary beginning in the region of the muscular part of the esophagus and passing into the oviduct; uterus wide, saclike, double, extending almost to the end of the tail. Walls of uterus wrinkled. Ovejector beginning at the connection of the two uteri, forming a long tube which extends to the vulva and ends in the short vagina, which is reddish brown. Viviparous. Length of larvae 0.25 mm, width 0.014 mm.

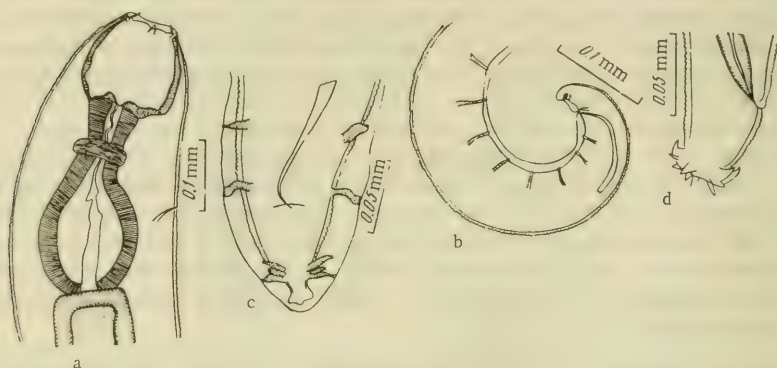


FIGURE 99. *Procammallanus slomei* Southwell and Kirschner, 1937:

a — anterior end, lateral; b — caudal end of male, lateral; c — same, ventral; d — caudal end of female, showing spines (after Southwell and Kirschner, 1937).

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 34; Southwell and Kirschner, 1937, pp. 245–265.

Procammallanus sphaeroconchus Tornquist, 1931 (Figure 100)

Hosts: *Serranus* sp., *Teuthis* sp.

Localization: small intestine.

Distribution: Gulf of Suez.

Description (after Tornquist, 1931). Red to reddish brown forms in life. The body narrows more markedly in the female than in the male from the anterior part of the posterior part of the esophagus. It then widens slightly again at the buccal capsule. Buccal capsule rounded. Mouth with 6 cuticular thickenings in the form of small rectangles inside the mouth, parallel to its long side. Excretory system in the form of the letter H.

Male. Measurements not given. Length of buccal capsule 0.094 mm. Nerve ring situated 0.25 mm from the cephalic end. Anterior part of esophagus 0.437–0.484 mm long, posterior part 0.484–0.530 mm long.

Posterior end with 7 pairs of subventral preanal papillae. The space between the second and third pairs, counting from the cloaca, is the largest, that between the pairs near the cloaca the smallest. Five pairs of postanal caudal papillae. The second and fourth pairs are subventral and extend onto the caudal wings. The other papillae are lateral. The first pair, counting from the cloaca, is situated slightly before the second, the third slightly

before the fourth. The most widely spaced caudal papillae are the second and third pairs. Right spicule 0.320 mm long, left spicule 0.133 mm. Right spicule with small wings, slightly flattened.

Female. Length 10.873–21.341 mm, maximum width 0.219–0.200 mm. Depth of buccal capsule 0.109–0.140 mm. Nerve ring situated 0.265–0.343 mm from the cephalic end. Anterior part of esophagus 0.533–0.640 mm long, posterior part 0.577–0.702 mm. Vulva situated 4.134–8.112 mm from the cephalic end, without lips. Wall of buccal capsule 0.011 mm thick. Wall of basal ring 0.017 mm thick. Vagina 0.100 mm long. Ovejector 1.36 mm long, connected with a ventrally directed part of the uterus, 1.2 mm long. Uterus ending 0.350 mm before the rectum, situated 1.3 mm from the cephalic end. Oviduct directed posteriorly 1.55 mm long. Ovary 4.33 mm long. Tail 0.234–0.312 mm long. Viviparous.

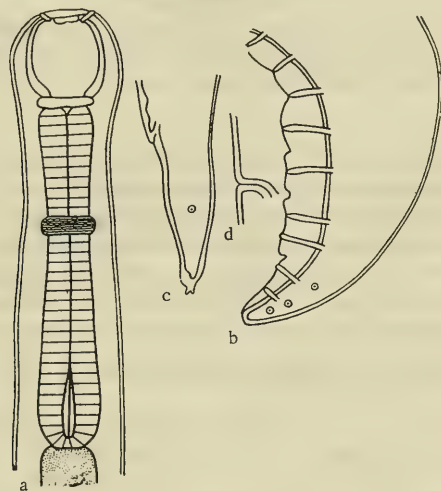


FIGURE 100. *Procammallanus sphaeroconchus* Tornquist, 1931:

a — anterior end; b — caudal end of male, lateral; c — caudal end of female, lateral; d — region of vulva, lateral (after Tornquist, 1931).

References: Skrjabin, Shikhobalova, Soboley, Paramonov, and Sudarikov, 1954, p. 34; Tornquist, 1931, pp. 306–312; Yamaguti, 1961b, p. 46.

Procammallanus spiculogubernaculus Agarwal, 1958 (Figure 101)

Host: *Heteropneustes fossilis*.

Localization: intestine.

Distribution: India.

171 Description (after Agarwal, 1958).

Male. Length 3.68 mm, width 0.088 mm; length of buccal capsule 0.06 mm, width 0.036 mm; anterior part of esophagus 0.24 mm long, 0.044 mm wide, posterior part 0.3 mm long, width 0.036 mm wide. Nerve ring situated 0.12 mm from cephalic end. Tail blunt, conical. Seven pairs

of caudal papillae, four pairs preanal and three pairs postanal. Right spicule 0.344 mm long, left spicule 0.05 mm. Gubernaculum 0.05 mm long, incompletely fused with the smaller spicule. Caudal wings absent.

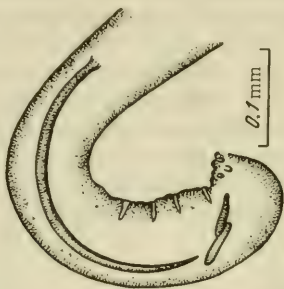


FIGURE 101. *Procammallanus spiculogubernaculus* Agarwal, 1958.

Caudal end of male, lateral (after Agarwal, 1958).

Female. Length 4.84 mm, width 0.088 mm; length of buccal capsule 0.08 mm, width 0.048 mm; anterior part of esophagus 0.32 mm long, 0.06 mm wide, posterior part 0.046 mm long, 0.048 mm wide. Rectum 0.05 mm long. Nerve ring situated 0.142 mm, excretory pore 0.232 mm from cephalic end. Tail 0.1 mm long, tapering, pointed, with bifid end. Vulva situated behind middle of body, 2.64 mm from the cephalic end, distinctly raised above the surface. Length of vagina 0.608 mm.

Reference: Agarwal, 1958, pp. 348–349.

Procammallanus sp. Ali, 1956

Host: *Ophiocephalus gachua*.

Localization: stomach.

Distribution: India.

Description (after Ali, 1956).

Male unknown.

Female. Length 5.542 mm, maximum width 0.23 mm. Buccal capsule barrel-shaped, 0.061 mm long and 0.085 mm wide. Nerve ring situated 0.13 mm, excretory pore 0.22 mm from the cephalic end. Esophagus 0.475 mm long, i. e. $1/12$ of length of body. Muscular part of esophagus 0.186 mm long, glandular part 0.289 mm. Vulva situated in middle of body, 2.5 mm from cephalic end. Tail 0.065 mm long. Two appendages at the end of the tail. Buccal capsule with a spiral thickening which does not extend to its anterior end.

References: Ali, 1956, pp. 15–16; Yamaguti, 1961b, p. 46.

172 *Procammallanus* sp. Vuylsteke, 1964 (Figure 102)

Host: fish.

Localization: intestine.

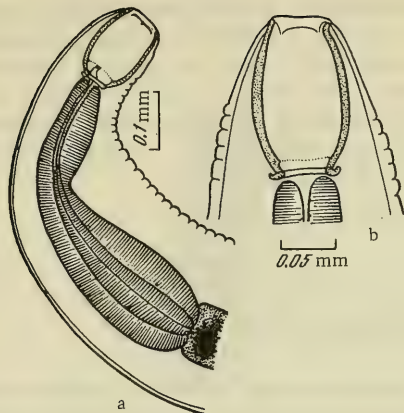


FIGURE 102. *Procammallanus* sp. Vuylsteke, 1964:

a — anterior end; b — cephalic end (after Vuylsteke, 1964).

Distribution: Africa.

Description (after Vuylsteke, 1964). One specimen in bad condition. Transverse striation of cuticle with intervals of 0.012 mm at the posterior end of the esophagus. Length of esophagus 0.490 mm.

Reference: Vuylsteke, 1964, pp. 64—66.

Procammallanus sp. Mawson, 1957 (Figure 103)

Host: *Sigmanum nebulosus*.

Localization: intestine.

Distribution: Australia.

Description (after Mawson, 1957b).

Male unknown.



FIGURE 103. *Procammallanus* sp. Mawson, 1957

Anterior end of female, lateral (after Mawson, 1957b).

Female. Length 19 mm. Buccal capsule 0.12 mm long, 0.11 mm wide, including the thickness of the walls (0.015 mm). Excretory pore situated 0.4 mm from the cephalic end. Anterior part of esophagus 0.43 mm long, posterior part 0.75 mm. Tail conical, 0.28 mm long, with simple, rounded end. Vulva not raised above the surface, situated almost a third of the length of the body from the cephalic end. Uterus filled with spirally coiled larvae 0.45 mm long, with a long tail.

Reference: Mawson, 1957b, p.178.

173 Genus *Spirocamallanus* Olsen, 1952

Diagnosis. Procamallaninae. Buccal capsule not divided into lateral valves; inner wall of capsule with spiral thickenings which are either continuous or consist of interrupted ridges. Esophagus divided into a muscular anterior and a glandular posterior part; posterior part usually longer. Caudal wings present in males; to 14 pairs of caudal papillae. Gubernaculum absent. Two spicules, of the same or of different length, of similar or different form. Numerous spine-shaped processes present or absent on the tail of females. Vulva situated in posterior half of body. Viviparous. Parasites of fish and amphibians.

Type species: *Spirocamallanus spiralis* (Baylis, 1923) Olsen, 1952.

Spirocamallanus spiralis (Baylis, 1923) Olsen, 1952 (Figure 104)

Synonym: *Procamallanus spiralis* Baylis, 1923

Hosts: *Heterobranchus anguillaris*, *Synodontis eupterus*.

Localization: stomach and intestine.

Distribution: North Africa.

Historical review

The description of the species was given in two works (1923a,b): in the first Baylis described a male and in the second males and a female. Tornquist (1931) gave a description of the species based partly on Baylis' material (from the second host) and partly on collections from Sparidae and Labridae from the Gulf of Suez. This material was caught by the expedition led by Jägerskiöld (1909). In Volume IV of the "Key to Parasitic Nematodes" (1954) a list of the hosts of *P. spiralis* is given according to the above two authors, but the locality is mentioned only for Jägerskiöld's collection. A year before Volume IV of the "Key" was published, a work by Winter (1953) appeared which was not known to the authors of the above survey. Winter recorded the species (which he placed in the genus *Spirocamallanus*, in agreement with Olsen, 1952), in marine fishes caught near the coast of Mexico. He gives a description (based on females), stating that the Mexican specimens are identical in all important characters with *Spirocamallanus spiralis* (Baylis, 1923) Olsen, 1952. The identification is based on the structure of the buccal capsule and of the anterior and posterior end of the body. The species

is widely distributed, occurring in fish which are quite unrelated systematically and in their ecology (Winter, 1953, p. 138).

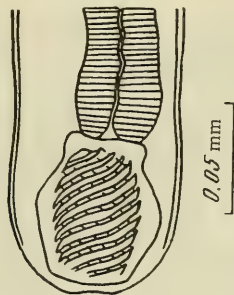


FIGURE 104. *Spirocamallanus spiralis* (Baylis, 1923).
Cephalic end, lateral (after Baylis, 1923b).

Campana-Rouget (1961a) mentioned that the number of species of *Spirocamallanus* parasitizing in marine fishes is very small compared with the number of species in freshwater fish; there are only a few species. It is unlikely that the same species is found in hosts with a different biology.

174 Tornquist's description does not exactly agree with the description of Baylis: the buccal capsule contains 9 spiral ribs instead of 12, the proportions of the two parts of the esophagus are different, and the males are markedly larger. Campana-Rouget therefore proposed to remove Tornquist's specimens from *S. spiralis* and named them *Spirocamallanus tornquisti* (= *Procamallanus spiralis* sensu Tornquist, 1931).

Winter's specimens from Mexican fish also belong to *S. tornquisti*.

Description (after Baylis, 1923b). Buccal capsule not divided into two lateral valves. Tridents absent. Inner side of buccal capsule with spirally arranged riblike thickenings. Cephalic end slightly laterally compressed.

Male. Length 7 mm, maximum width 0.16 mm. Length of buccal capsule 0.07 mm. Distance from cephalic end to end of muscular anterior part of esophagus 0.45 mm; length of esophagus 0.78 mm. Right spicule 0.15 mm long, left spicule about 0.10 mm.

Seven pairs of riblike papillae in the caudal wings, 2 pairs of short pedunculate papillae situated ventrally, and one pair at the anterior lip and one pair at the posterior lip of the cloaca. There are apparently some further small papillae near the end of the tail.

Female. Length 22.25 mm, maximum width 0.40 mm. Length of buccal capsule 0.09 mm. Distance from anterior end of body to nerve ring 0.27 mm, to end of muscular part of esophagus 0.58 mm, to end of glandular part 1.10 mm, and to vulva 9.25 mm. Tail 0.16 mm long.

Only one ovary; posterior branch of uterus ending blind. Vagina extending straight posteriorly from the vulva. Viviparous.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 34; Baylis, 1923a, pp. 27–28; 1923b, pp. 137–139; Campana-Rouget, 1961, pp. 24–25; Jägerskiöld, 1909, p. 66; Tornquist, 1931, p. 400; Winter, 1953, pp. 137–139; Yamaguti, 1961b, p. 46.

Spirocamallanus amarali (Vaz and Pereira, 1934) Olsen, 1952
(Figure 105)

Synonym: *Procamallanus amarali* Vaz and Pereira, 1934

Host: *Leporinus* sp.

Localization: small intestine.

Distribution: Brazil.

Description (after Vaz and Pereira, 1934).

Male (one specimen). Length 9.25 mm, width 0.28 mm. Mouth rounded, buccal capsule large, more or less spherical, with strongly chitinized walls and with 8 chitinized ribs. A chitinous ring between buccal capsule and muscular part of esophagus. Buccal capsule 0.07 mm long and 0.062 mm wide. Muscular part of esophagus club-shaped, gradually widening posteriorly, 0.31 mm long. It is followed by a ventricle about 0.6 mm long.

Four papillae around the mouth, two median and two lateral. Nerve ring surrounding anterior part of esophagus slightly behind its middle, 0.2 mm from the cephalic end. Posterior end curved ventrally, with narrow caudal wings. Spicules of different length, strongly chitinized, tapering distally; larger spicule 0.44 mm long, smaller spicule 0.24 mm. Fourteen pairs of caudal papillae: 8 pairs preanal, 3 pairs adanal, and 3 pairs postanal, the last two postanal pairs situated immediately behind the anus and the other pair near the end of the tail. Anus situated 0.14 mm from the posterior end.

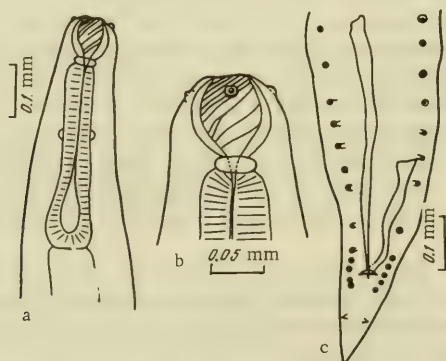


FIGURE 105. *Spirocamallanus spiralis* (Vaz and Pereira, 1934):
a, b — anterior end, different aspects; c — caudal end of male, ventral
(after Vaz and Pereira, 1934).

Female not known.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 30; Vaz and Pereira, 1934, pp. 96—97.

Spirocamallanus bagarii (Karve and Naik, 1951) Olsen, 1952
(Figure 106)

Synonym: *Procamallanus bagarii* Karve and Naik, 1951

Hosts: *Bagarius bagarius* (= *Bagarius yarrelli*), *Callichrous bimaculatus*.

Localization: stomach.

Distribution: India.

Description (after Karve and Naik, 1951). Striation of cuticle distinct, annulation of body coarse, more distinct in the anterior half. Cephalic end truncate and slightly wider than the other part of the body. Buccal capsule identical in both sexes, strongly chitinized, wider than long, usually cup-shaped but more or less spherical in some specimens. Projecting, interrupted ribs on the inner surface of the capsule. At the bottom of the capsule are three cuticular folded processes directed anteriorly, one dorsal and two subventral. They correspond to the three sectors of the esophagus. Mouth large, elliptical or rounded, surrounded by three pairs of cephalic papillae. Muscular anterior part of esophagus club-shaped posteriorly. The esophagus opens into the intestine through a triradial opening which is bordered by three valves that project into the intestine. Excretory pore large, situated slightly behind the connection of the two parts of the esophagus. Cervical papillae situated at the level of the nerve ring or slightly before it.

176 Male. Length 4.95–9.5 mm, width 0.15–0.25 mm. Transverse striation of cuticle with intervals of 0.0025 mm. Width of cephalic end 0.13–0.17 mm. Buccal capsule 0.092–0.112 mm long and 0.11–0.135 mm wide. Muscular anterior part of esophagus 0.48–0.7 mm long, glandular posterior part 0.49–0.77 mm. Nerve ring surrounding anterior part of esophagus 0.195–
177 0.265 mm from the cephalic end. Cervical papillae situated 0.18–0.25 mm from the cephalic end.

Caudal region markedly thicker than preceding part of body and strongly curved ventrally. Caudal wings and parallel caudal muscles well developed. Tail 0.055–0.07 mm long. Seven pairs of long, pedunculate, riblike preanal and at least 6 pairs of postanal pairs of papillae. Counted from the posterior end, the first pair is lateral, the second subdorsal, and the third, fourth, and sixth pairs are situated close together. Two spicules of different length but difficult to see, particularly the left. Right spicule thicker, 0.15–0.165 mm long. Left spicule weakly chitinized, thin, 0.13–0.145 mm long. Both spicules with thin end. Gubernaculum chitinized, 0.033–0.0475 mm long.

Female. Length 14.1–16.8 mm, width 0.3–0.35 mm. Transverse striation of cuticle with intervals of 0.003 mm. Width of cephalic end 0.16–0.19 mm. Buccal capsule 0.11–0.13 mm long and 0.135–0.17 mm wide. Muscular anterior part of esophagus 0.83–0.95 mm long, glandular posterior part 0.71–0.92 mm. Nerve ring surrounding anterior part of esophagus 0.26–0.3 mm from the cephalic end, cervical papillae situated 0.255–0.275 mm from the cephalic end. Tail 0.11–0.15 mm long, with three spines at the end. A single pair of caudal papillae, situated about 0.055 mm from end of tail. Vulva situated 7.85–9.6 mm from cephalic end, passing into a small, oblique, tubular part which continues posteriorly into the muscular vagina which is 0.55–0.61 mm long. The vagina extends posteriorly for some distance, parallel to the ventral body wall and then diverges, runs parallel to the dorsal wall for a short distance and then unites with the two opposite branches of the uterus. The muscular vagina is surrounded by unicellular glands at its beginning. Cuticle swollen in the region of the vulva. Viviparous.

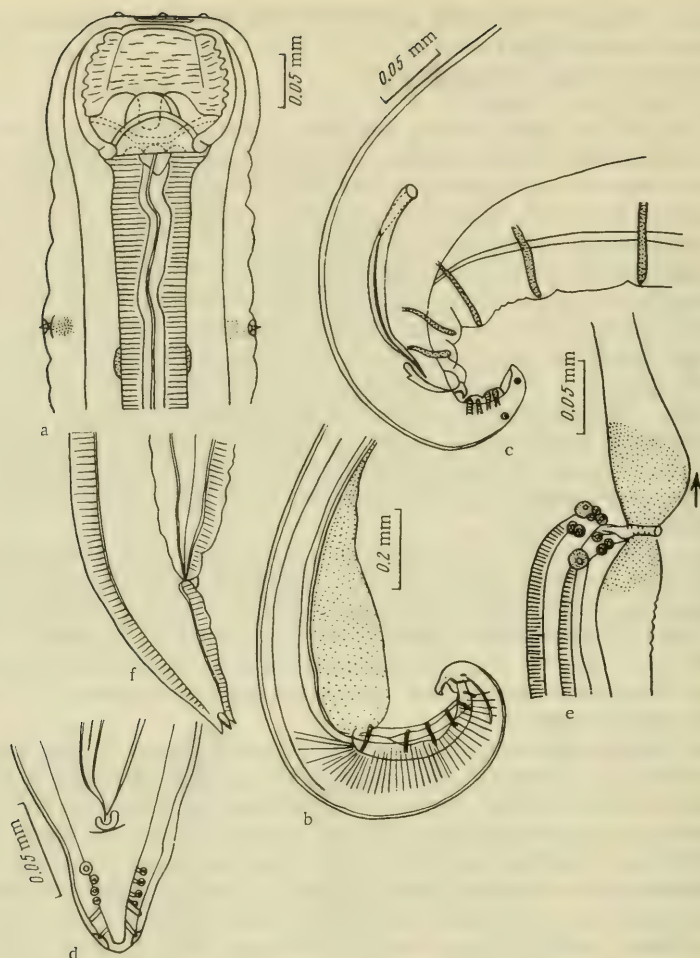


FIGURE 106. *Spirocamallanus bagarii* (Karve and Naik, 1951):

a — anterior end of female, dorsal; b, c — caudal end of male, lateral; d — same, ventral; e — region of vulva; f — tail of female, lateral (after Karve and Naik, 1951).

Reference: Karve and Naik, 1951, pp. 30–34.

Spirocamallanus barroslimai (Pereira, 1935) Olsen, 1952
(Figure 107)

Synonym: *Procamallanus barroslimai* Pereira, 1935

Host: sardine.

Localization: small intestine.

Distribution: Brazil.

Description (after Pereira, 1935). Small reddish nematodes.

Male. Length 3.1 mm, width 0.14 mm; cuticle with fine transverse striation. Mouth rounded, buccal capsule large, almost spherical, with about 20 chitinized lines which are wider at the base and become gradually narrower anteriorly and to the left, most of them interrupted. They form the wall of the buccal capsule, which is 0.03 mm long and 0.04 mm wide. Esophagus club-shaped, 0.28 mm long, maximum width 0.07 mm; glandular part about 0.5 mm long. Caudal end forming a spiral, tapering; caudal wings 178 weakly developed, beginning 0.15 mm from posterior end. Tail 0.10 mm long. The ventral side of the tail shows distinct, oblique muscles and 6 pairs of subventral papillae which form two rows, three pairs preanal and three pairs postanal. Spicules small, almost of the same length, 0.05 and 0.06 mm.

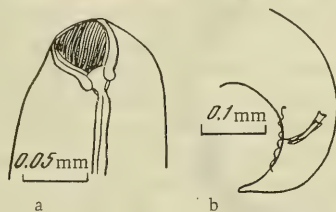


FIGURE 107. *Spirocamallanus barroslimai* Pereira, 1935:

a — anterior end; b — posterior end of male, lateral (after Pereira, 1935).

Female unknown.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.30; Pereira, 1935, pp.60—61.

Spirocamallanus cearensis (Pereira, Vianna Diaz, and Azevedo, 1936) Olsen, 1952 (Figure 108)

Synonym: *Procamallanus cearensis* Pereira, Vianna Diaz, and Azevedo, 1936

Hosts: definitive — *Astyanax bimaculatus vittatus*; intermediate — *Diaptomus cearensis* and *D. azevedoi*; reservoir — *Curimatus elegans*.

Localization: small intestine.

Distribution: Brazil.

Description (after Pereira, Vianna Diaz, and Azevedo, 1936). Small, reddish nematodes.

Male. Length about 4 mm, width about 0.18 mm. Cuticle with moderately distinct transverse striation. Mouth rounded, buccal capsule large, spherical, with 18 chitinized lines which are wider at the base and become thinner anteriorly and toward the left and disappear at the margin of the mouth. Width of buccal capsule about 0.04 mm. Esophagus club-shaped, 0.27 mm long. Between esophagus and buccal capsule is a vestibulum in the form of a chitinized ring on which the 0.008-mm-long buccal capsule is situated.

Glandular part of esophagus about 0.03 mm long; two large nuclei near its posterior end. Nerve ring situated about 0.16 mm, excretory pore about 0.20 mm from the cephalic end.

Posterior end curved ventrally, strongly tapering, with very narrow caudal wings. Cloaca situated 0.15 mm from posterior end.

The ventral surface shows thin oblique muscles and 7 pairs of papillae arranged in two subventral rows, four pairs preanal and three pairs postanal. Spicules short, chitinized, almost of the same length, about 0.057 mm long.

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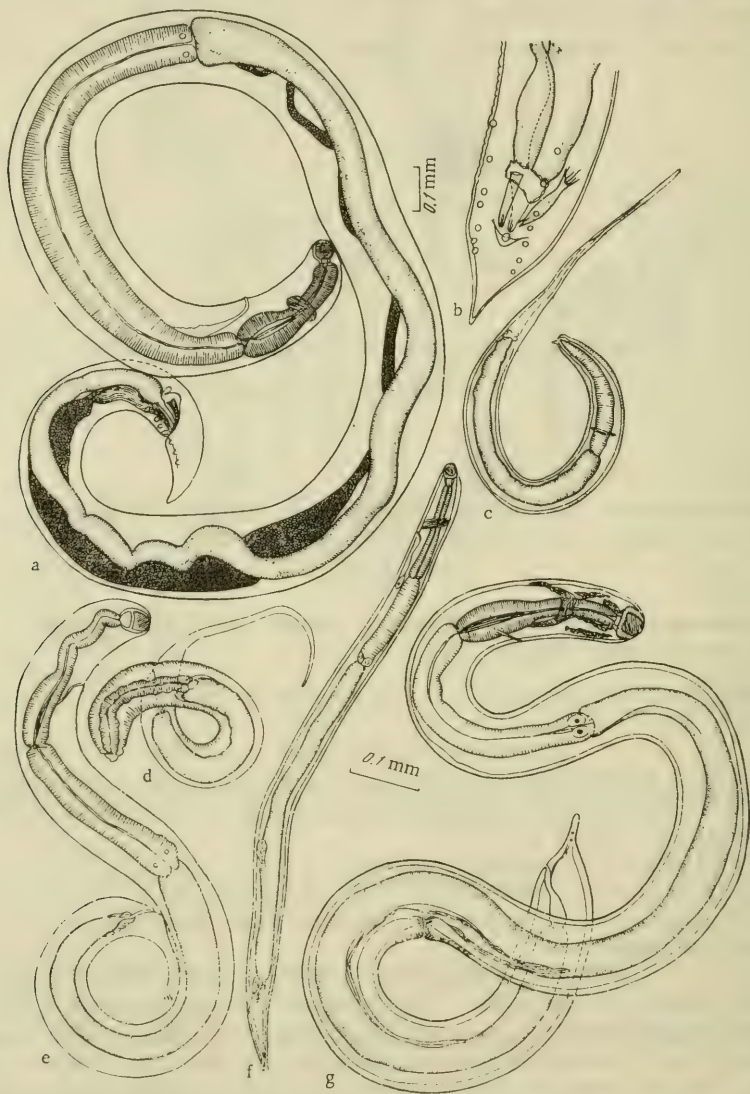


FIGURE 108. *Spirocamallanus cearensis* (Pereira, Vianna Diaz, and Azevedo, 1936): a — male, general view; b — caudal end of male, ventral; c — larva from uterus of mature female; d — first-stage larva from body cavity of *Diaptomus*; e — second-stage larva from body cavity of *Diaptomus cearensis*; f, g — third-stage larvae (after Pereira, Vianna Diaz, and Azevedo, 1936).

180 Female. Length 10.3–14 mm, width 0.28–0.42 mm. Cuticle with moderately distinct transverse striation. Width of buccal capsule 0.04–0.05 mm; walls of capsule with 18 chitinized lines. Esophagus 1.75–1.93 mm long. Nerve ring situated 0.12–0.16 mm, excretory pore 0.21–0.26 mm from the cephalic end. Anus situated 0.08–0.14 mm from end of tail. Tail markedly tapering.

Vulva situated 6.3–6.4 mm from end of tail. Uteri diverging; posterior ovary absent. Viviparous.

Development. The adult females parasitize in the small intestine of fish: *Astyanax bimaculatus vittatus* (Tetragonopterinae; Characidae). Eggs develop into larvae in the uterus. The larvae move in all directions in the uterus and collect in the posterior branch, including the ovejector. The uterus becomes filled with coiled masses or long strings of larvae. The fully developed uterus extends to the posterior end of the esophagus anteriorly and to the anus posteriorly.

Length of larvae 0.46–0.56 mm, width 0.03 mm. Cuticle with fine transverse striation. Cephalic end truncate, mouth simple. There is a distinctly chitinized conical process dorsally at the cephalic end. Esophagus narrow, cylindrical, 0.10–0.11 mm long. Anus situated 0.21–0.22 mm from end of tail. Tail relatively long, about 40–45% of the length of the body, tapering and ending in a thin pointed process.

Larvae taken from a female survive in fresh water for many days. When placed in water, the larvae sink slowly, often adhering to the bottom with the tail.

Diaptomus cearensis and *D. azevedoi* were experimentally infected. The larvae of *Spirocamallanus* penetrated the wall of the intestine and settled in the body cavity without becoming encysted. After about 3 days the first molt takes place. The larvae may remain in the body cavity of the intermediate host for a long time. *Diaptomus* apparently easily tolerates infection with this parasite. The larvae move freely in the body cavity.

We always found only a single larva of *Spirocamallanus* in a specimen of *Diaptomus*.

Description of larvae considered to be second-stage larvae from the body cavity of *Diaptomus*. Length 0.66–0.77 mm, width 0.03–0.04 mm. Buccal capsule of the same structure as in the adult, except that there are only 9–10 chitinized diagonal thickenings. Width of buccal capsule 0.016–0.020 mm, length 0.012 mm. Muscular part of esophagus 0.14 mm long, glandular part 0.12–0.13 mm. Intestine straight, rectum short, straight, anus situated 0.073 mm from end of tail. Tail short, ending in 3 or 4 small denticles. The authors consider this larva infective for fingerlings of *Curimatus elegans*, the reservoir host.

After entering the fish, the larvae settle in the beginning of the small intestine, where the second molt takes place and become third-stage larvae.
181 The genital primordium now develops. In a female larva 1.0 mm long the genital primordium consists of a row (0.04 mm) of cells situated 0.32 mm from end of tail. The oviduct is recognizable in a larva 1.9 mm long; it is situated 0.84 mm from end of tail. The genital primordium has a distinct outline in a female larva 2.4 mm long.

The buccal capsule has now the typical striation with 8–11 lines.

It is assumed that the definitive host may become infected directly by eating *Diaptomus*, i. e. the life cycle of the parasite may be completed

without a reservoir host. The authors assume that only one molt takes place in the crustacean, although there are probably two molts, but the first is difficult to observe because it is completed soon after the larvae enter the intermediate host, and the differences between first- and second-stage larvae are very small.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 32; Leuckart, 1876, pp. 109–112; Pereira, Vianna Diaz, and Azevedo, 1936, pp. 209–226.

Spirocamallanus chimuzensis Freitas and Ibanez, 1968

Host: *Pygidium punctulatum*.

Localization: intestine.

Distribution: Peru.

Description (after Freitas and Ibanez, 1968).

Male. Length 12–13 mm, width 0.24–0.25 mm. Cuticle longitudinally striated, body tapering at both ends. Mouth round, buccal capsule strongly chitinized, its posterior part in the form of a ring, capsule 0.078–0.083 mm long and 0.058–0.067 mm wide. Nine spiral ribs (4 complete and 5 incomplete) on the inside of the buccal capsule.

Esophagus club-shaped; muscular part 0.40–0.42 mm long, 0.12–0.13 mm wide. Glandular part well developed, 0.57–0.58 mm long and 0.12–0.13 mm wide. Intestine more or less straight. Nerve ring situated 0.18 mm, excretory pore 0.20 mm from the cephalic end. Larger spicule 0.22–0.23 mm, smaller spicule 0.16–0.17 mm long. Gubernaculum absent. Anus situated 0.13 mm from end of tail. Caudal wings absent. Caudal papillae small, 6 pairs, three preanal and three postanal. Genital duct directed anteriorly. Testis more or less sinuous, not extending to the beginning of the intestine.

Female. Length 34–37 mm, width 0.63–0.67 mm. Buccal capsule 0.093 mm long and 0.073–0.080 mm wide. Inner surface of buccal capsule with 4 spiral ribs (three complete and one incomplete). Muscular part of esophagus 0.58–0.62 mm long, 0.15–0.17 mm wide; glandular part 0.78–0.85 mm long, 0.15–0.17 mm wide. Nerve ring situated 0.23–0.25 mm, excretory pore 0.27 mm from the cephalic end.

Uteri didelphic, amphidelphic. Lips of vulva not protruding, situated in anterior half of body, 20.26 mm from end of tail. Ovejector directed posteriorly, 1.46 mm long. Anterior half of duct situated before the vulva, 182 posterior half behind the vulva. Rectum 0.18 mm long. Anus situated 0.13–0.18 mm from end of tail. Viviparous.

Reference: Freitas and Ibanez, pp. 146–148.

Spirocamallanus fariasi (Pereira, 1935) Olsen, 1952 (Figure 109)

Synonym: *Procamallanus fariasi* Pereira, 1935

Hosts: *Leporinus* sp., *Pygocentris* sp.

Localization: small intestine.

Distribution: Brazil.

Description (after Pereira, 1935). Small, reddish nematodes.

Male. Length 3.5–5.0 mm, width 0.18–0.27 mm. Cuticle with fine transverse striation. Mouth rounded, buccal capsule large, barrel-shaped, with relatively thick walls and with 20 chitinized lines which are wider at the base and become narrower anteriorly and to the left; many of them are interrupted. These formations occupy about the two posterior thirds of the capsule; length of buccal capsule 0.09 mm, width 0.04–0.06 mm.

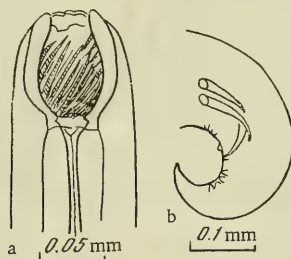


FIGURE 109. *Spirocamallanus fariasi* (Pereira, 1935):

a — cephalic end, lateral; b — caudal end of male, lateral (after Pereira, 1935).

Esophagus club-shaped, 0.27–0.31 mm long, maximum width 0.07–0.09 mm; glandular part 0.5 mm long. Nerve ring situated 0.16–0.17 mm from the cephalic end. Caudal end curved ventrally, tapering, 0.11–0.13 mm long. Spicules small, of almost the same length, smaller spicule 0.08–0.09 mm long, larger spicule 0.09–0.10 mm long. Ventral side with distinct oblique muscles and 9 pairs of papillae in two subventral rows, three pairs precloacal and six pairs postcloacal.

Female unknown.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.32; Pereira, 1935, pp.61–62.

Spirocamallanus fulvidraconis (Li, 1935) Olsen, 1952
(Figures 110, 111)

Synonyms: *Procamallanus fulvidraconis* Li, 1935; *Procamallanus siluri* Osmanov, 1964

Hosts: definitive — *Pseudobagrus fulvidraco*, *Parasilurus asotus*, *Liocassis ussuriensis*, *Leuciscus lehmanni*, *Barbus brachycephalus*, *Pelecus cultratus*, *Aspiolucius esocinus*, *Glyptosternum reticulatum*, *Pseudoscaphirhynchus kaufmanni*; intermediate — *Cyclops*.

Localization: esophagus and intestine.

184 Distribution: China, USSR (Far East, Middle Asia).

Historical review

Osmanov (1954) described *Procamallanus* sp. from numerous hosts in a study of the helminth fauna of fish in Uzbekistan. Osmanov (1964) named the

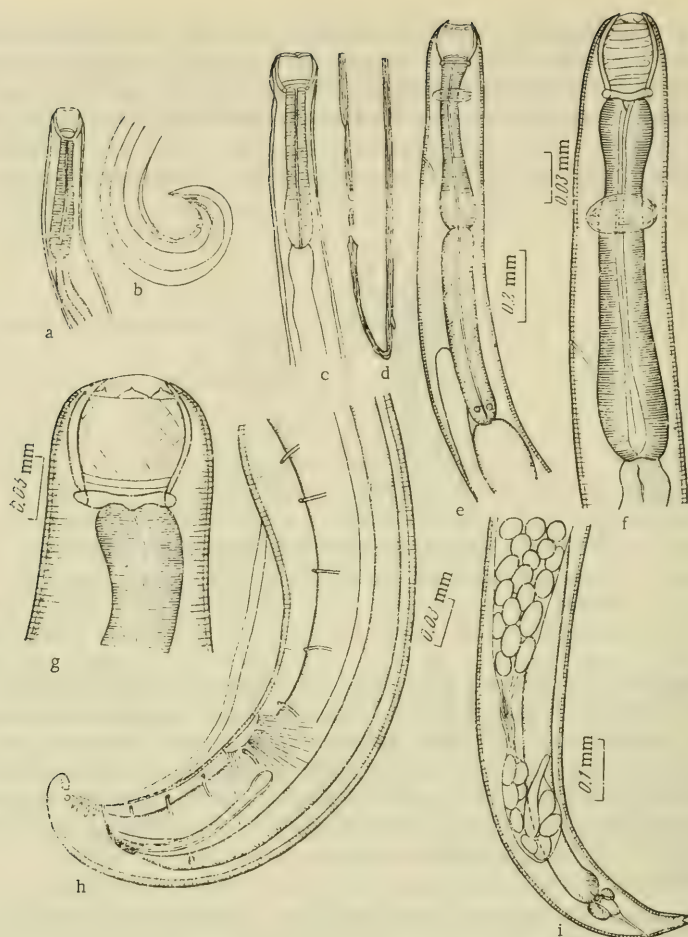


FIGURE 110. *Spirocamallanus fulvidraconis* (Li, 1935):

a — anterior end of male; b — posterior end of male, lateral; c — anterior end of female; d — posterior end of female; e, f — anterior end, lateral; g — cephalic end; h — caudal end of male, lateral; i — caudal end of female, lateral (a-d — after Osmanov, 1964; e-i — after Skryabina, 1969).

parasite *Procamallanus siluri*. On a study of a species of *Procamallanus* from *Pseudoscaphirhynchus kaufmanni*, Skryabina (1969) concluded that *P. siluri* Osmanov is identical with *Spirocamallanus fulvidraconis* (Li, 1935).

Description (after Li, 1935). Cephalic end truncate, mouth rounded, surrounded by 6 small papillae, four submedian and two amphids. Buccal capsule barrel-shaped, its walls with continuous spiral thickenings. Esophagus divided into a muscular anterior part and a longer glandular part. Cuticle thick, coarsely striated.

Male. Length 3.95–5.35 mm, width 0.05–0.1 mm. Length of buccal capsule 0.04–0.05 mm, width 0.07–0.075 mm. Nerve ring situated

0.135–0.160, excretory pore 0.270–0.280 mm from the cephalic end. Muscular part of esophagus 0.320–0.340 mm long, glandular part 0.360–0.430 mm.

Spicules of markedly different length and form: right spicule thinner and 0.180–0.240 mm long; left spicule wide, resembling a gubernaculum, 0.025–0.032 mm long. Tail 0.040–0.055 mm long, slightly curved ventrally; the muscles in the curved part are well developed and resemble a pseudo-sucker. Caudal wings symmetrical, supported by 9 pairs of pedunculate papillae.

Female. Length 9.8–12.25 mm, width 0.15–0.18 mm. Length of buccal capsule 0.05–0.055 mm, width 0.08–0.09 mm. Nerve ring situated 0.165–0.175 mm, excretory pore 0.3–0.33 mm from the cephalic end. Muscular part of esophagus 0.4–0.41 mm long, glandular part 0.42–0.53 mm. Vulva situated at about the last fifth of the body, 2.2–2.6 mm from end of tail. Branches of uterus diverging, posterior branch ending blind, without an ovary; viviparous. Tail conical, ending in three short, blunt processes. Tail 0.110–0.120 mm long.

Description (after Osmanov, 1964, as *Procamallanus siluri*). Small, viviparous forms. Mouth without lips. Buccal capsule usually longer than wide in males; this character is variable in females, but the capsule is wider usually than long.

Male. Length 3.14–4.8 mm, width 0.084–0.147 mm. Buccal capsule 0.058–0.074 mm long and 0.051–0.066 mm wide. Glandular part of esophagus 0.4–0.53 mm long, muscular part 0.29–0.34 mm. Larger spicule 0.12–0.168 mm long, smaller spicule 0.025–0.030 mm. Eight or 9 pairs of preanal papillae and 5 pairs of postanal papillae. Caudal wings present.

Female. Length 5.2–9.5 mm, width 0.109–0.231 mm. Buccal capsule 0.074–0.110 mm long and 0.085–0.131 mm wide. Muscular part of esophagus about 0.562 mm long, glandular part 0.804 mm. Vulva situated in posterior half of body. End of tail usually rounded.

Description (after Skryabina, 1969). Cuticle thick, striated. Buccal capsule usually as wide as long, but slightly longer than wide in some specimens; spiral thickenings on the capsule not present in all specimens. Esophagus divided into a muscular and a glandular part. Excretory pore situated below the nerve ring. Cervical papillae situated above the connection between muscular and glandular part of esophagus.

186 Male. Length 3.40 (2.80–3.40) mm, width of cephalic end at the buccal capsule 0.068 (0.064–0.070) mm, width in middle of body 0.13 (0.11–0.15) mm. Length of buccal capsule 0.064 (0.064–0.069) mm, width 0.052 (0.052–0.060) mm. Nerve ring situated 0.15 (0.15–0.17) mm, excretory pore 0.28 (0.27–0.28) mm from the cephalic end. Muscular part of esophagus 0.26 (0.26–0.40) mm long, glandular part 0.43 (0.36–0.45) mm. Tail (from the cloaca) 0.052 (0.043–0.052) mm long. Larger spicule 0.17 (0.11–0.17) mm long, smaller spicule 0.021 (0.021–0.026) mm. Nine pairs of preanal papillae and 5 pairs of postanal papillae. Small caudal wings present. Tail with processes at the end.

Female. Length 5.80 (3.80–5.90) mm, width at cephalic end 0.12 (0.086–0.12) mm, near the vulva 0.13 (0.11–0.15) mm, and near the anus 0.052 (0.047–0.056) mm. Buccal capsule 0.10 (0.077–0.101) mm long, 0.12 (0.077–0.12) mm wide. Nerve ring situated 0.21 (0.13–0.21) mm, excretory pore 0.26 (0.23–0.26) mm, cervical papillae 0.56 mm from the cephalic end. Vulva situated behind middle of body, 3.18 (2.10–3.18) mm from the cephalic end.

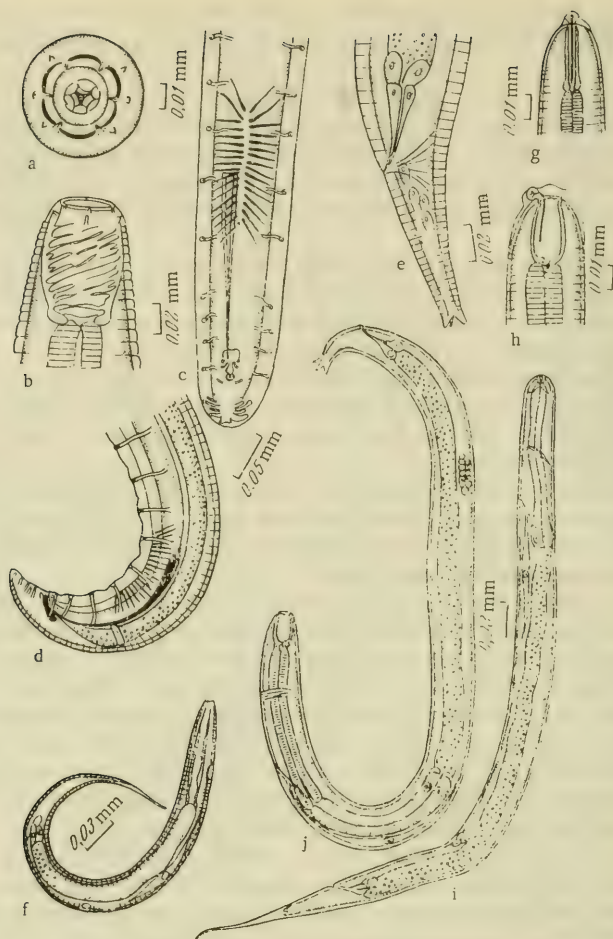


FIGURE 111. *Spirocamallanus fulvidraconis* (Li, 1935):

a — cephalic end of female, apical; b — same, lateral; c — caudal end of male, ventral; d — same, lateral; e — caudal end of female, lateral; f — larva from uterus; g — cephalic end of larva before first molt, buccal capsule not yet developed; h — cephalic end of larva immediately after first molt, buccal capsule already developed, remains of the shed cuticle visible; i — 6-day-old larva with small buccal capsule, simple esophagus, and thin tail; j — 14-day-old larva (5 days after first molt) with well-developed buccal capsule, differentiated esophagus, and with three processes at end of tail (after Li, 1935).

Muscular part of esophagus 0.48 (0.38–0.48) mm long, glandular part 0.063 (0.47–0.63) mm. Tail 0.10 (0.064–0.10) mm long. Tail with two processes at the end.

Development. Li (1935) found that *Spirocamallanus fulvidraconis* develops in the body cavity of *Cyclops serratus*, *C. vicinus*, and *C. magnus*. A larva which enters the water remains at the bottom, winding into a coil and unwinding regularly. *Cyclops* swallows

the larvae. Li noted that many larvae die when swallowed. After they reach the body cavity, the larvae begin to move and remain active until after the molt, when they coil and remain motionless.

Li observed only one larval molt in *Cyclops*, which he considered as the first, at room temperature 8–9 days after infection. He did not observe further molts during 5 weeks of observation. However, he noted morphological changes after 5–6 days (disappearance of the dorsal tooth, development of the buccal capsule, increase in the number of genital cells), which are characteristic for the second-stage larva. Li did not observe the first molt, and what he considered as the second stage was in fact the third.

Li gives a description of the first-stage larva and the development of its organs. The cephalic end bears a dorsal spine for piercing the intestinal wall of *Cyclops*.

The wall of the esophagus is very thin, and three nuclei of esophageal glands are visible at the base of the esophagus. Cell nuclei, renettes, are situated in the anterior third of the intestine. The intestine contains small granules mainly in the posterior part. The rectal glands are already well developed. The wall of the rectum forms a thin slit. The genital primordium is unicellular and situated behind the middle of the body. Tail long and tapering. Cuticle with distinct transverse striation.

187 The cuticle of a larva which has just passed out of the uterus is thin and coarsely striated. The only changes from the first stage are increase in thickness and in length. After the first molt the cuticle becomes very thick with distinct striation.

The buccal capsule changes markedly. In a larva which has just entered the water the cephalic end bears a dorsal spine; this is lost on the 5th day (probably during the first molt, when a small but distinct buccal capsule develops). After 8–9 days, before the second molt, the capsule becomes oblong with a narrow lumen. If pressure is applied to the cover glass, the inner lining of the capsule is displaced, while the buccal capsule widens to a form resembling that of the adult, but the inner surface is smooth, without thickenings.

In a newly hatched larva the nerve ring is situated in about the middle of the esophagus; when the glandular part develops, it is gradually displaced anteriorly until it is situated at the anterior fifth of the esophagus after the second molt.

The excretory pore is at first situated behind the middle of the esophagus. During development of the glandular part of the esophagus it is displaced to before the middle of the esophagus. From the pore posteriorly extends a long duct which ends in a large, club-shaped cell with a large nucleus. The nucleus of this cell is situated at the anterior third of the intestine in a newly hatched larva, but it moves anteriorly until it is situated in the middle of the posterior part of the esophagus in the mature larva.

Changes in the esophagus are marked during development. In the newly hatched larva the wall of the esophagus is very thin, particularly near its anterior end, with a wide lumen. After 2 or 3 days in the *Cyclops*, the wall of the esophagus becomes thicker and the lumen narrower. The division of the esophagus into two parts takes place at the second molt, and there is a distinct muscular anterior and a glandular posterior part. The esophagus increases to 3 times its original length in 3 weeks.

The cells of the intestine become larger and more numerous and contain pigment granules. The contents of the intestine of the newly hatched larva are small granules; after 2 or 3 days in the body cavity of *Cyclops*, the intestine becomes filled with yellow particles of irregular form. These particles increase in size but are discharged during the second molt or just after it, and the intestine contains then little or practically no solid matter. The reddish brown color of the intestine after the second molt is due to pigment granules concentrated around the nuclei of the cells of the intestine.

In a newly hatched larva the genital primordium is unicellular and situated behind the middle of the body. After 6 days (after the molt) it consists of 4 cells, after 14 days of more than 10 cells, and from then on it develops little.

The long, thin tail gradually decreases in size during growth, leaving an empty sheath. Before the second molt, a short, trifid tail, resembling that of the adult female, develops inside the old cuticle.

Larval growth in the body cavity of *Cyclops* (mm) (after Li, 1935)

| | Number of days | | | | | |
|--|----------------|-------|-------|-----------|-----------|-----------|
| | 0 | 3 | 6 | 10 | 14 | 21 |
| Length | 0.455 | 0.592 | 0.690 | 0.733 | 0.756 | 1.015 |
| Width | 0.030 | 0.035 | 0.036 | 0.040 | 0.037 | 0.044 |
| Distance of nerve ring from cephalic end | 0.040 | 0.050 | 0.073 | 0.075 | 0.072 | 0.088 |
| Distance of excretory pore from cephalic end | 0.058 | 0.065 | 0.102 | 0.117 | 0.125 | 0.146 |
| Length of esophagus | 0.092 | 0.105 | 0.150 | 0.282 | 0.275 | 0.320 |
| | | | | (2 parts) | (2 parts) | (2 parts) |
| Length of intestine | 0.210 | 0.310 | 0.412 | 0.400 | 0.422 | 0.596 |
| Length of tail | 0.152 | 0.165 | 0.145 | 0.045 | 0.055 | 0.055 |

References: Ivashkin and Khromova, 1964, pp.98–104; Osmanov, 1964, p.39; Skryabina, 1969, pp.146–151; Campana-Rouget, 1961, pp.425–433; Li, 1935, pp.103–113; Olsen, 1952, pp.173–215.

Spirocamallanus globoconchus (Ali, 1960) (Figure 112)

Synonym: *Procamallanus globoconchus* Ali, 1960

Host: *Rita hastata*.

Localization: gills.

Distribution: India.

Description (after Ali, 1960).

Male. Reddish in life, thin, particularly the anterior part, with truncate cephalic end. Posterior end pointed and with wide caudal wings. Length 6.3–7.4 mm, maximum width 0.12–0.14 mm. Dorsoventral width of cephalic end 0.08–0.10 mm. Cuticle 0.032 mm thick, transverse striation with intervals of 0.013 mm. There is also a very fine striation in the intervals. Nerve

ring surrounding anterior part of esophagus 0.23–0.28 mm from the cephalic end; excretory pore situated 0.30–0.36 mm from the cephalic end.

Buccal capsule nearly spherical, almost as wide as long (0.14–0.15 mm long and 0.12–0.14 mm wide). There is a characteristic thick-walled, hood-shaped formation at the apex and three shell-like formations and a pair of nodular chitinous formations at the base of the capsule, and several transverse linear thickenings on the wall of the capsule. Two pairs of submedian cephalic papillae and a pair of lateral amphids. Esophagus 1.23–1.48 mm long, $1/5$ of length of body. Muscular part of esophagus 0.50–0.54 mm long, glandular part 0.73–0.94 mm long.

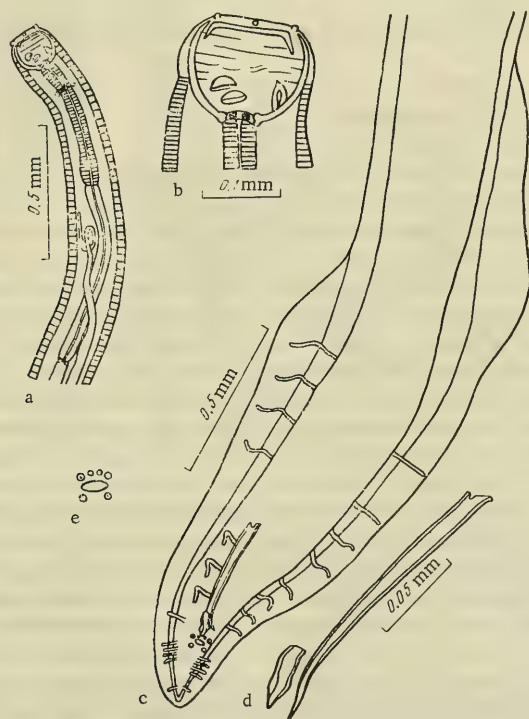


FIGURE 112. *Spirocamallanus globoconchus* (Ali, 1960):

a — anterior end; b — cephalic end; c — caudal end of male, ventral; d — spicules; e — arrangement of papillae around the cloaca (after Ali, 1960).

Tail pointed, with wide, asymmetrical wings. Left wing wider and longer than the right, 1.11 and 0.65 mm long, respectively. Thirteen pairs of pedunculate caudal papillae, 8 pairs preanal and 5 pairs postanal. The preanal papillae are equally spaced and larger than the postanal papillae. The first four pairs of postanal papillae form a group; the last pair is isolated at the end of the tail. Three pairs of small, sessile papillae situated around the anus; two of the pairs are larger than the third, which is situated medio-ventrally before the cloaca. The other two pairs are lateral, one before,

the other behind the cloaca. Spicules of different length and form. Right spicule longer, more or less needle-shaped, with widened anterior and pointed posterior end. Left spicule boat-shaped and more strongly chitinized. 190 Right spicule 0.15–0.18 mm long, left spicule 0.030–0.038 mm. Ratio of length of spicules about 5:1. Tail 0.032–0.036 mm long.

Female unknown.

References: Ali, 1960, pp.131–132; Olsen, 1952, pp.173–215.

Spirocamallanus gubernaculus (Khera, 1955)

(Figure 113)

Synonym: *Procamallanus gubernaculus* Khera, 1955

Host: *Rita rita*.

Localization: intestine.

Distribution: India.

Description (after Khera, 1955). Threadlike nematodes, tapering at both ends. Cuticle thin, delicately striated with intervals of 0.003–0.004 mm. Mouth surrounded by 6 papillae, two lateral and four submedian. Buccal capsule chitinized, barrel-shaped. Its walls with 16–18 interrupted spiral thickenings. A pair of finger-shaped thickenings parallel to the longitudinal axis of the buccal capsule. Esophagus divided into a club-shaped muscular anterior part and a longer, cylindrical glandular posterior part. Intestine wider than posterior part of esophagus, with wide lumen. Three small rectal gland cells at the connection between intestine and rectum. Nerve ring surrounding anterior part of esophagus. Cervical papillae very small.

Male. Length 8.5 mm, width 0.109 mm. Length of buccal capsule 0.062 mm, width 0.039 mm. Anterior part of esophagus 0.41 mm long, posterior part 0.645 mm. Nerve ring situated 0.155 mm, cervical papillae 0.39 mm from the cephalic end. Tail tapering, blunt, conical. Caudal wings well developed. Eleven pairs of caudal papillae, 5 pairs preanal and 6 pairs postanal. The five pairs of preanal papillae are equally spaced, riblike, pedunculate. The first pair of postanal papillae is ventral, pedunculate. The last two pairs are lateral, sessile, widely spaced. Left spicule absent, right spicule colorless, 0.29 mm long. Dorsal wall of cloaca thickened. Gubernaculum strongly chitinized, knife-shaped, brown to dark brown, with a convexity 0.066 mm long in the middle of the ventral surface.

Female. Length 18.25 mm, width 0.141 mm. Length of buccal capsule 0.062 mm, width 0.042 mm. Anterior part of esophagus 0.28 mm long, posterior part 0.925 mm. Rectum 0.07 mm long. Nerve ring situated 0.113 mm, cervical papillae 0.3 mm, excretory pore 0.2 mm from the cephalic end. Tail 0.175 mm long, a pair of papillae on the ventral side at the end. Anterior lip of anus directed posteriorly, closing the anus. Lips of vulva forming a small, projecting appendage directed posteriorly, 0.05 mm long. Vulva situated in posterior half of body, 10.25 mm from the cephalic end. The muscular vagina extends to the base of the appendage and then turns posteriorly, extending for 0.4 mm, where it passes into the short common duct of the uterus, which has two branches, an anterior and a posterior. 191 The anterior branch ends in an ovary 2.6 mm behind the esophagus. The posterior branch ends blind 1.3 mm before the anus.

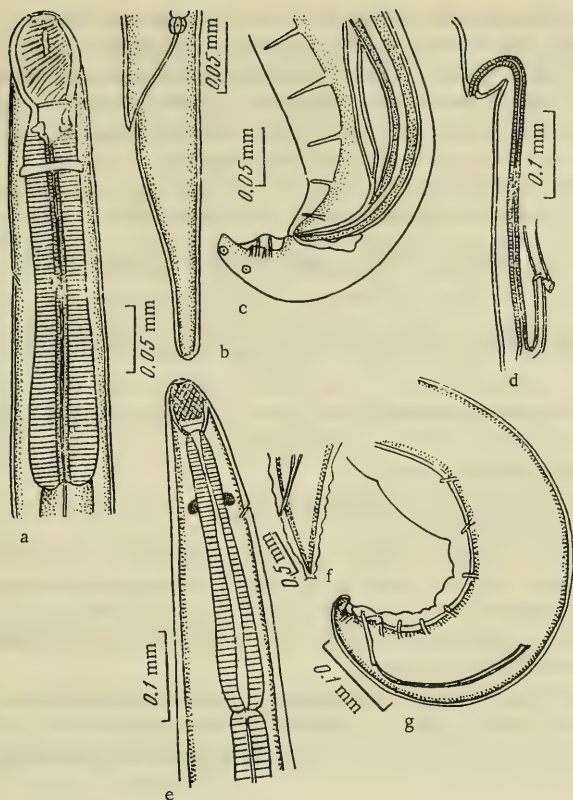


FIGURE 113. *Spirocamallanus gubernaculus* (Khera, 1955):

a — anterior end, lateral; b — caudal end of female, lateral; c — caudal end of male, lateral; d — region of vulva, lateral; e — anterior end of male, lateral; f — caudal end of female, lateral; g — caudal end of male, lateral (a — d — after Khera, 1955; e — g — after Sood, 1968).

Description (after Sood, 1968). Cuticle finely transversely striated with intervals of 0.003–0.006 mm. Body with tapering ends. Mouth surrounded by 6 papillae, two lateral and four submedian. Buccal capsule barrel-shaped, with spiral thickenings. Esophagus divided into a muscular anterior and a glandular posterior part.

Male. Length 4.25–4.31 mm, width 0.09–0.1 mm. Dorsoventral width of cephalic end 0.021–0.028 mm. Length of buccal capsule 0.049–0.051 mm, width 0.025–0.038 mm. Muscular anterior part of esophagus 0.27–0.32 mm long, 0.047–0.05 mm wide; glandular posterior part 0.39–0.44 mm long, 0.041–0.05 mm wide. Nerve ring situated 0.11–0.13 mm, excretory pore 0.16 mm from the cephalic end.

Caudal wings well developed. Tail 0.025–0.03 mm long. Twelve pairs of caudal papillae, 7 pairs preanal and 5 pairs postanal. The first pair of postanal papillae is displaced toward the cloaca; the other four pairs are situated close together. Only right spicule present, weakly chitinized, widened anteriorly and tapering posteriorly, 0.21–0.22 mm long. Gubernaculum dark, 0.065–0.07 mm long.

Female. Length 7.59–9.06 mm, width 0.19–0.20 mm. Dorsoventral width of cephalic end 0.025–0.032 mm. Length of buccal capsule 0.06–0.07 mm, width 0.03–0.032 mm. Muscular anterior part of esophagus 0.31–0.39 mm long, 0.03–0.05 mm wide; glandular posterior part 0.49–0.60 mm long, 0.049–0.05 mm wide. Nerve ring situated 0.13–0.145 mm, excretory pore 0.17–0.19 mm from the cephalic end. Tail 0.07–0.081 mm long, with two processes at the end. Vulva situated in posterior half of body, 4.81–5.70 mm from the cephalic end. Viviparous.

References: Khera, 1955, pp.245–247; Sood, 1968, pp.94–96.

Spirocamallanus hilarii (Vaz and Pereira, 1934) Olsen, 1952
(Figure 114)

Synonym: *Procamallanus hilarii* Vaz and Pereira, 1934

Host: *Salminus hilarii*.

Localization: small intestine.

Distribution: Brazil.

Description (after Pereira, 1934). Anterior end curved dorsally, whitish, other part of body dark. Cuticle transversely striated. Mouth rounded, buccal capsule with chitinized walls, and with about 16 ribs from one side of the capsule to the other; some of the smaller (second-order) ribs are connected anteriorly.

The muscular part of the esophagus is separated from the buccal capsule by a strongly chitinized ring; it gradually becomes wider posteriorly, about 0.41 mm long and 0.1 mm wide. Glandular part of esophagus very long.

(193)

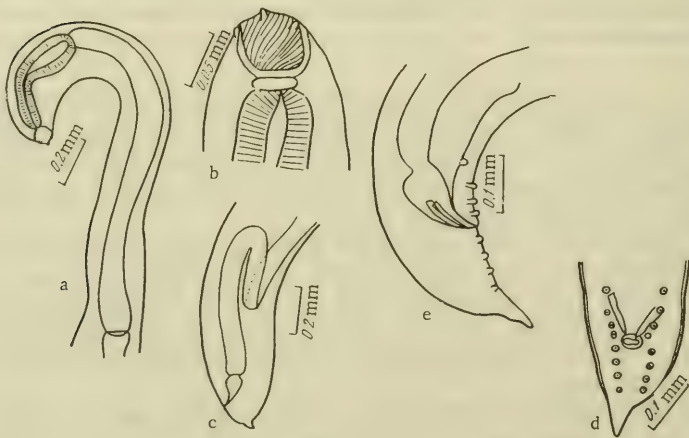


FIGURE 114. *Spirocamallanus hilarii* (Vaz and Pereira, 1934):

a — anterior end; b — cephalic end; c — caudal end of female, lateral; d — caudal end of male, ventral; e — same, lateral (after Vaz and Pereira, 1934).

Three pairs of small cephalic papillae; one lateral, two median. Nerve ring situated about 0.2 mm, excretory pore 0.36 mm from the cephalic end.

Male. Length 6 mm, width 0.2 mm. Buccal capsule 0.057 mm long, 0.057 mm wide. Glandular part of esophagus 1.5 mm long. Tail curved ventrally, with oblique muscle fibers directed to the middle of the ventral surface.

Spicules of almost the same length, very small, 0.082 mm and 0.062 mm long; smaller spicule slightly wider at the proximal end.

Tail with 8 pairs of widely spaced pedunculate ventral papillae, 3 pairs preanal, 2 pairs adanal, and 3 pairs postanal. Anus situated 0.16 mm from end of tail. Tail tapering sharply behind the last pair of papillae.

193 Female: Length 14 mm, width 0.36 mm. Buccal capsule 0.062 mm long and 0.062 mm wide. Glandular part of esophagus 2.02 mm long. Viviparous. Body almost entirely filled with embryos. Vulva situated in middle of body. Intestine forming a loop about 0.5 mm from the posterior end. Anus situated 0.12 mm from end of tail. Tail blunt, with a spine about 0.028 mm long at the end.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 33; Vaz and Pereira, 1934, pp. 97-99.

Spirocammallanus hyderabadensis (Ali, 1956)
(Figure 115)

Synonym: *Procamallanus hyderabadensis* Ali, 1956

Host: *Mystus seenghala*.

Localization: stomach.

Distribution: India.

Description (after Ali, 1956). Body reddish in life, very thin, with slightly narrowing ends, cephalic end truncate, tail pointed in both sexes. Cuticle transversely striated. Intervals of cuticular striation about 0.004 mm in middle of body. Cephalic end with one pair of submedian papillae and lateral amphids. Walls of buccal capsule thickened at the base and gradually becoming thinner anteriorly. Buccal capsule nearly cylindrical.

194 Male. Length 3.03-3.13 mm, width 0.077 mm. Excretory pore situated 0.20 mm, nerve ring 0.066-0.069 mm from the cephalic end. Length of buccal capsule 0.04-0.05 mm, width 0.025-0.030 mm. Muscular part of esophagus 0.24-0.31 mm long, glandular part 0.35-0.42 mm. Length of esophagus 0.59-0.73 mm, about 1/5 of length of body. Testis situated in anterior third of body, extending to base of muscular part of esophagus, where it turns posteriorly. Ejaculatory duct short and narrow. Caudal wings well developed, 0.290-0.329 mm long.

Ten pairs of riblike caudal papillae, 6 pairs preanal and 4 pairs postanal. A pair of cuticular processes, characteristic for the genus, situated immediately behind the third pair of postanal papillae. Last pair of postanal papillae situated near end of tail. Spicules of different length and form, right spicule longer, 0.18-0.20 and 0.042-0.050 mm long, respectively. Left spicule widest in the middle, with hooklike end and wide proximal part. Right spicule of uniform width most of its length, slightly wider at proximal end and pointed at distal end. Tail 0.068 mm long.

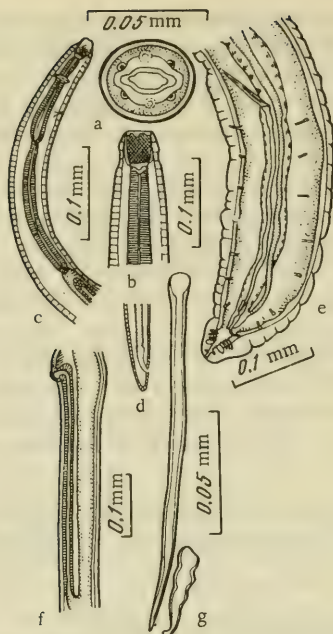


FIGURE 115. *Spirocamallanus hyderabadensis* Ali, 1956:

a — cephalic end, apical; b — same, lateral; c — anterior end of female, lateral; d — posterior end of female, lateral; e — caudal end of male, ventral; f — region of vulva, lateral; g — spicules, ventral (after Ali, 1956).

Female. Length 5.58–6.01 mm, width 0.130 mm. Excretory pore situated 0.26 mm, nerve ring 0.130–0.138 mm from the cephalic end. Buccal capsule 0.073–0.075 mm long and 0.039–0.040 mm wide. Muscular part of esophagus 0.269–0.370 mm long, glandular part 0.370–0.400 mm. Length of esophagus 0.63–0.77 mm, about $\frac{1}{9}$ of length of body. One ovary, situated in region of esophagus. Oviduct passing into the seminal vesicle. Vagina long, extending straight to the vulva, which protrudes and has distinct lips. Posterior uterus ending in a blind sac. Viviparous. Tail 0.036 mm long.

Reference: Ali, 1956, pp. 11–13.

195 *Spirocamallanus iheringi* (Travassos, Artigas, and Pereira, 1928)
Olsen, 1952 (Figure 116)

Synonym: *Procamallanus iheringi* Travassos, Artigas, and Pereira, 1928

Hosts: *Salminus hilarii*, *Hoplias* sp., *Tetragonopterus* sp., *Leporinus* sp., *Anostomatinae* sp.

Localization: intestine and pyloric caeca.

Distribution: Brazil.

Description (after Travassos, Artigas, and Pereira, 1928). Cuticle with transverse striation. Mouth rounded, buccal capsule large, with a chitinized lining in the form of spiral ribs; 4–5 large ribs in males, 14–16 smaller ribs in females. Anterior end of esophagus with a chitinous ring which separates it from the buccal capsule; esophagus club-shaped, glandular part long. Intestine forming one or two coils. Nerve ring situated 0.20–0.28 mm from the cephalic end, in about middle of esophagus; excretory pore situated 0.4 mm from the cephalic end.

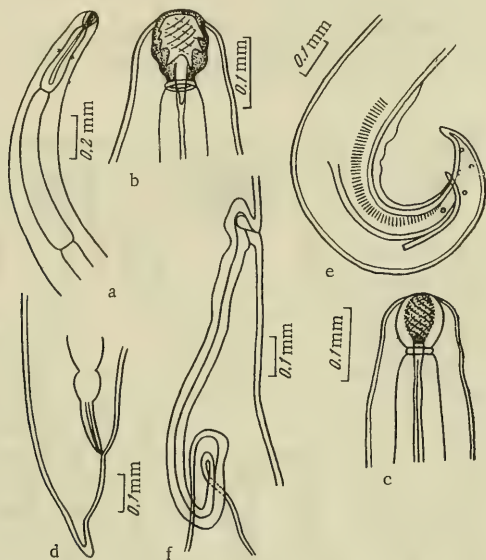


FIGURE 116. *Spirocamallanus iheringi* (Travassos, Artigas, and Pereira, 1928):

a — anterior end; b — cephalic end of male; c — cephalic end of female; d — caudal end of female, lateral; e — caudal end of male, lateral; f — ovejector (after Travassos, Artigas, and Pereira, 1928).

Male. Length 12 mm, width 0.3 mm. Buccal capsule 0.072–0.080 mm long, 0.056–0.064 mm wide. Muscular part of esophagus 0.31–0.37 mm long, 0.08 mm wide; glandular part 0.75 mm long. Tail curved ventrally, with narrow caudal wings which extend 0.5 mm before the anus; oblique muscles on the ventral surface of the caudal end, from the cloaca to the end of the caudal wings. Five pairs of caudal papillae, one pair preanal, one pair adanal, three pairs postanal. Cloaca situated about 0.10–0.12 mm from end of tail; tail conical. Spicules 0.24–0.25 and 0.52–0.53 mm long, respectively.

Female. Length 16–21 mm, width 0.5–0.8 mm. Buccal capsule 0.088–0.096 mm long and 0.072–0.080 mm wide. Muscular part of esophagus 0.41–0.45 mm long, 0.10–0.11 mm wide; glandular part 0.80–0.84 mm long. Vulva situated in about middle of body; ovejector very long (1.6 mm) and thin (0.065 mm). Branches of uterus diverging. Viviparous. Anus situated 0.16–0.24 mm from end of body, rectum 0.20 mm long. Tail conical, 0.08–0.10 mm long, ending in a finger-shaped process.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.33; Travassos, Artigas, and Pereira, 1928, p.21.

Spirocamallanus inopinatus (Travassos, Artigas, and Pereira, 1928) Olsen, 1952 (Figure 117)

Synonym: *Procamallanus inopinatus* Travassos, Artigas, and Pereira, 1928

Host: *Leporinus* sp.

Localization: intestine.

Distribution: Brazil.

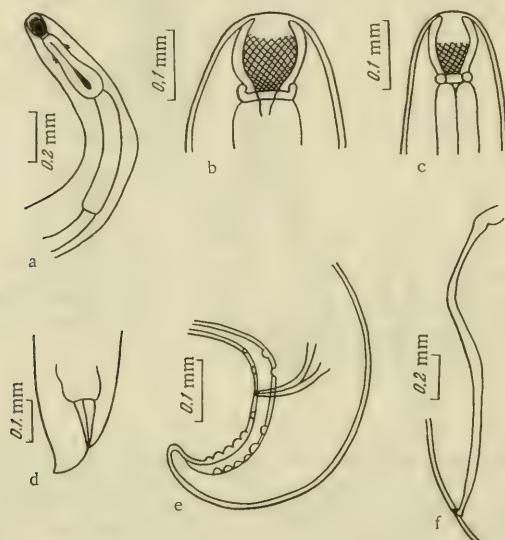


FIGURE 117. *Spirocamallanus inopinatus* (Travassos, Artigas, and Pereira, 1928):

a — anterior end; b — cephalic end of female; c — cephalic end of male; d — caudal end of female, lateral; e — caudal end of male, lateral; f — ovejector (after Travassos, Artigas, and Pereira, 1928).

Description (after Travassos, Artigas, and Pereira, 1928). Cuticle 197 striated. Excretory pore situated 0.32 mm, nerve ring 0.25—0.32 mm from cephalic end, around middle of esophagus. Mouth rounded, buccal capsule strongly chitinized; inner surface of capsule with small ribs arranged in a spiral, about 15 ribs in both sexes; the ribs do not extend to the margins of the capsule, occupying about 2/3 of its length and of characteristic appearance. Esophagus club-shaped.

Male. Length 5.12 mm, width 0.24 mm. Length of buccal capsule 0.09 mm. Muscular part of esophagus 0.36 mm long, 0.10 mm wide; glandular part 0.56 mm long, 0.10 mm wide. Tail curved ventrally, the narrow wings with 8 pairs of papillae, 2 pairs preanal and 6 pairs postanal, the first

five pairs situated closer to the end of the tail and close together, the last pair slightly more widely separated. Spicules of almost the same length, about 0.120 mm; cloaca situated about 0.20 mm from end of tail which is finger-shaped.

Female. Length 16–30 mm, width 0.8 mm. Length of buccal capsule 0.12 mm. Muscular part of esophagus 0.45 mm long, 0.13 mm wide; glandular part 0.76 mm long, 0.16 mm wide. Viviparous. Vulva situated near middle of body, ovejector long and thin, its single part about 1.4 mm long, 0.056 mm wide. Rectum about 0.24 mm long; anus situated 0.20 mm from posterior end. Tail conical, blunt.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 33; Travassos, Artigas, and Pereira, 1928, pp. 20–21.

Spirocamallanus istiblenni Noble, 1966 (Figure 118)

Host: *Istiblennius zebra*.

Localization: intestine.

Distribution: Hawaii.

Description (after Noble, 1966). Mouth round, without lips. In apical view the anterior part of the buccal capsule has 8 lateral processes and is surrounded by weak folds. The orange-brown buccal capsule is lined with 13 or 14 spiral thickenings. Between the buccal capsule and the body wall are 4 elongate buccal sinuses, two dorsal and two ventral. They are apparently part of the osmoregulatory system. Two excretory ducts extend along the entire body and unite at the level of the glandular part of the esophagus, forming an excretory sinus (with a large nucleus), which opens to the outside through a short duct. Posterior part of intestine and rectal gland supported by distinct muscle fibers.

Male. Length 14.9 mm, width 0.221 mm. Length of buccal capsule 0.075 mm, width 0.072 mm. Muscular part of esophagus 0.325 mm long, glandular part 0.485 mm. Excretory pore situated 0.400 mm, nerve ring 0.208 mm from cephalic end.

Six pairs of preanal and 3 pairs of postanal caudal papillae. Caudal wings curved anteriorly and contiguous ventrally. Ratio of length of spicules 3:2. Right spicule 0.274 mm long, left spicule 0.184 mm. Anus surrounded by 4 small papillae. Tail finger-shaped, sometimes with three small processes. Tail 0.166 mm long.

Female. Length 21.50 mm, width 0.336 mm. Length of buccal capsule 0.077 mm, width 0.077 mm. Muscular part of esophagus 0.397 mm long, glandular part 0.488 mm. Excretory pore situated 0.400, nerve ring 0.220 mm from cephalic end. Vulva situated slightly before middle of body, 8.200 mm from cephalic end. Vagina extending posteriorly for about 1.3 mm. Distal part of vagina 0.4 mm long, with a thick muscular wall. Posterior ovary usually much shorter than the anterior ovary, probably rudimentary, 0.850 mm long, containing cells resembling immature eggs of the anterior ovary; eggs in posterior ovary 0.008×0.010 mm large. The large anterior ovary is coiled into rings and together with the oviduct is about 10 mm long, or half the length of the body; ripe eggs in anterior ovary 0.011×0.015 mm large. The oviduct narrows before the seminal vesicle, and the seminal vesicle narrows before the wide, thin-walled uterus, the walls of which contain gland cells. Anus situated 0.177 mm from end of tail.

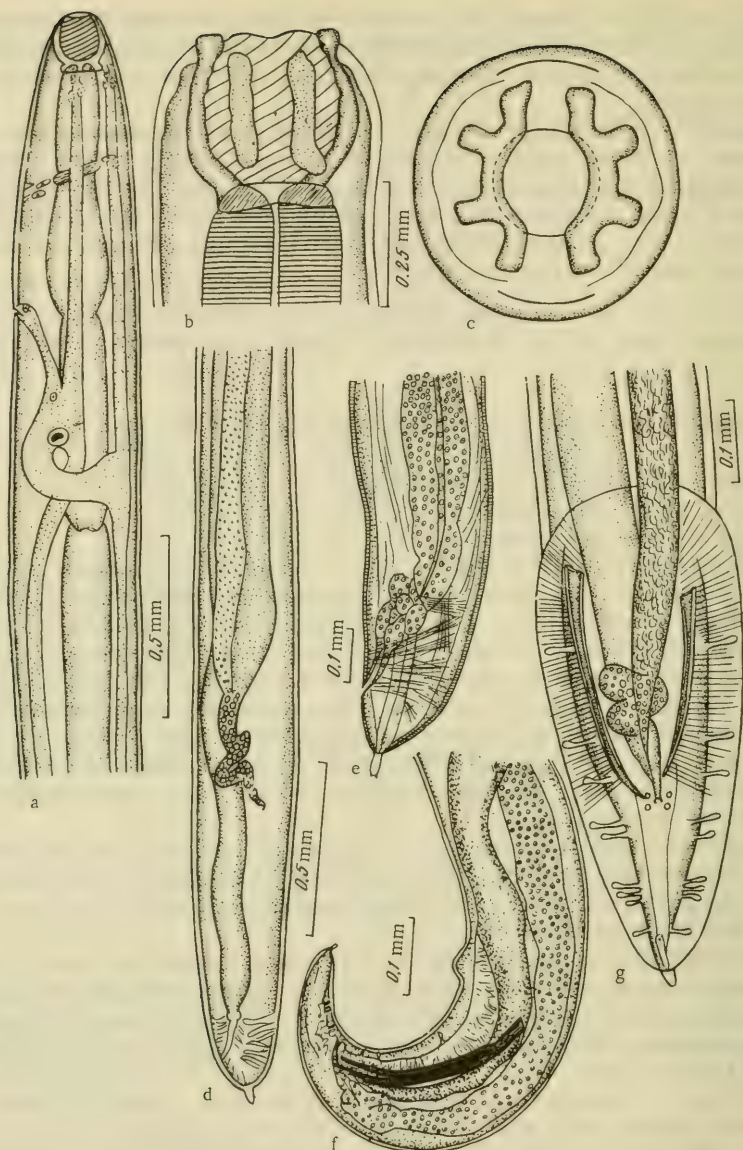


FIGURE 118. *Spirocamallanus istiblenni* Noble, 1966:

a — anterior end, lateral; b — cephalic end, lateral; c — same, apical; d — posterior end of female, lateral; e — caudal end of female, lateral; f — caudal end of male, lateral; g — same, ventral (after Noble, 1966).

Reference: Noble, 1966, pp. 360—366.

Spirocamallanus kerri (Pearse, 1933) Olsen, 1952
(Figure 119)

Synonym: *Procamallanus kerri* Pearse, 1933

Host: *Glossogobius giurus*.

Localization: intestine.

Distribution: Thailand.

Description (after Pearse, 1933).

Male unknown.

Female. Length 5.45 mm, width 0.08 mm. Length of buccal capsule 0.04 mm. Muscular part of esophagus 0.29 mm long, glandular part 0.32 mm. Tail 0.1 mm long. Buccal capsule chitinized, barrel-shaped, with thick walls, strongly striated on the inner side. Tail narrowed in the middle, curved ventrally, sometimes pointed, with two small spines at the end. Vulva situated between the first and second thirds of the body.

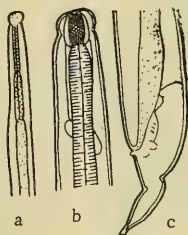


FIGURE 119. *Spirocamallanus kerri* (Pearse, 1933):

a, b — cephalic end of female; c — caudal end of female,
lateral (after Pearse, 1933).

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.33; Pearse, 1933, pp.185—186; Olsen, 1952, pp.173—215.

200 *Spirocamallanus mazabukae* Yeh, 1957
(Figure 120)

Host: freshwater fish.

Localization: intestine.

Distribution: Africa.

Description (after Yeh, 1957). Slender nematodes, with finely transversely striated cuticle. Buccal capsule with 12 complete oblique ribs in both sexes. Esophagus divided into a muscular and a glandular part.

Male. Length 11.8—14.9 mm, width 0.16—0.18 mm. Cervical papillae situated 0.14—0.18 mm, excretory pore 0.44—0.47 mm from cephalic end. Nerve ring situated in about middle of muscular part of esophagus, 0.22—0.24 mm from cephalic end. Buccal capsule 0.09 mm long, 0.06 mm wide.

Muscular anterior part of esophagus 0.39–0.42 mm long, the longer glandular part 0.95–1.05 mm. Cloaca situated 0.15–0.18 mm from end of tail. Caudal wings well developed, supported by pedunculate papillae. The first of the 3 pairs of preanal papillae is separated from the others; the 6 pairs of postanal papillae are almost equally spaced. On each side of the cloaca are 2 pairs of large papillae. The longer, thick, right spicule is 0.470–0.473 mm long, the thinner, less strongly chitinized left spicule has a bifid end and is 0.272–0.283 mm long. Gubernaculum absent.

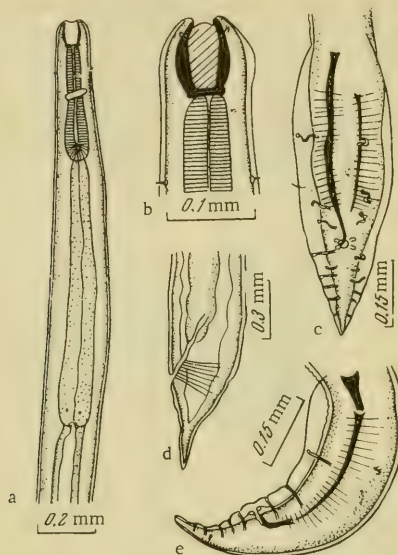


FIGURE 120. *Spirocamallanus mazabukae* Yeh, 1957:

a — anterior end, ventral; b — cephalic end, lateral, showing the buccal capsule; c — caudal end of male, ventral; d — caudal end of female, lateral; e — caudal end of male, lateral, left spicule intact, right spicule torn off (after Yeh, 1957).

Female. Length 16.2 mm, maximum width 0.18 mm. Cervical papillae situated 0.16 mm, excretory pore 0.46 mm, nerve ring 0.27 mm from cephalic end. Length of buccal capsule 0.10 mm, width 0.075 mm. Muscular part of esophagus 0.46 mm long, glandular part 0.85 mm. Tail 0.19 mm long, markedly narrowing in the middle and tapering at the end. Vulva situated slightly before middle of body, 7.5 mm from cephalic end. Vagina at first directed posteriorly and then turning anteriorly.

References: Campana-Rouget, 1961a, pp.24–25; Yeh, 1957, pp.126–128.

201 *Spirocamallanus monotaxis* Olsen, 1952 (Figure 121)

Host: *Monotaxis grandoculis*.

Localization: intestine.

Distribution: Hawaii.

Description (after Olsen, 1952b). Cephalic end smooth, rounded, papillae indistinct. Cuticle thin, transversely striated with intervals of 0.004 mm. Buccal capsule barrel-shaped, with spiral thickenings. A ring-shaped thickening at the base of the capsule. Muscular anterior part of esophagus club-shaped, glandular posterior part also club-shaped. A short valve apparatus between glandular part of esophagus and intestine.

Male. Length 15.6–17.7 mm, maximum width 0.26–0.29 mm. Posterior end sharply curved ventrally. Length of buccal capsule 0.11 mm, width 0.07 mm, its walls with 16 spiral thickenings. Anterior part of esophagus 0.39–0.44 mm long, maximum width 0.08–0.09 mm. Nerve ring situated 0.28–0.30 from cephalic end. Excretory pore situated 0.19 mm behind the nerve ring in a male 15.8 mm long. Posterior part of esophagus 0.76 mm long, maximum width 0.11–0.12 mm. Intestine 0.08 mm wide.

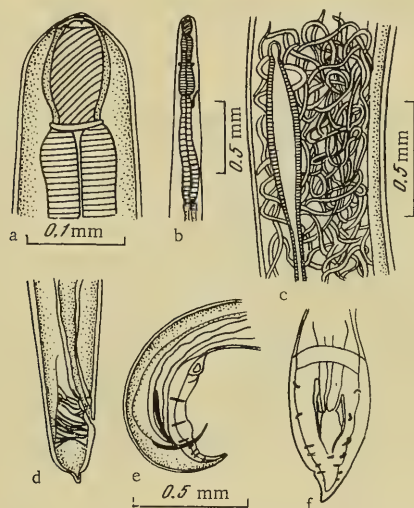


FIGURE 121. *Spirocamallanus monotaxis* Olsen, 1952:

a — cephalic end, lateral; b — anterior end, lateral; c — region of vulva; d — caudal end of female, lateral; e — caudal end of male, lateral; f — same, ventral (after Olsen, 1952b).

In a specimen 17.7 mm long the testis begins 1.46 mm from the cephalic end and extends posteriorly for 7.0 mm. It narrows and passes into the seminal vesicle, which extends posteriorly for 7.1 mm. After a second narrowing, it passes into the ejaculatory duct which is 1.7 mm long.

Caudal wings 0.67 mm long, beginning on the ventral surface, where they are united. Seven pairs of pedunculate caudal papillae, 3 pairs preanal, one pair adanal, and 3 pairs postanal. Spicules of similar form but of different length: right spicule 0.29–0.32 mm long, left spicule 0.23–0.24 mm. Tail 0.20 mm long.

Female. Length 34.0 mm, maximum width 0.55 mm. Buccal capsule 0.11 mm long and 0.08 mm wide, with 10 spiral thickenings on the walls.

Anterior part of esophagus 0.59 mm long, maximum width 0.12 mm. Nerve ring situated 0.37 mm from cephalic end. Posterior part of esophagus 1.11 mm long, maximum width 0.13 mm. Intestine 0.12 mm wide.

Vulva situated 13.6 mm from cephalic end, i. e. at about $3/8$ of the length of the body. Vagina directed posteriorly, its distal part short (0.07 mm), with thin wall near the vulva, which is followed by a swollen muscular part about 0.72 mm long. Then follows a narrow tube to 3.9 mm behind the vulva. Uterus very wide, filling the body cavity. It is united anteriorly with the ovary, which extends to the esophagus anteriorly and beyond the vulva posteriorly. Posterior branch of uterus blind. Embryos in uterus about 0.34 mm long and 0.018 mm wide.

Rectum 0.31 mm long. There are numerous muscle bundles near the anus extending across the body cavity. Tail with small conical end 0.04 mm long, with two small, teatlike processes visible only under high magnification. Tail 0.24 mm long.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 34; Olsen, 1952b, pp. 197–198; Yamaguti, 1961b, p. 45.

Spirocamallanus murrayensis (Johnston and Mawson, 1940) Olsen, 1952 (Figure 122)

Synonym: *Procamallanus murrayensis* Johnston and Mawson, 1940

Hosts: *Pseudaphritis urvillei*, *Percalates colonorum*, *Plectroplites ambiguus*.

Localization: intestine (?) — not given.

Distribution: Australia.

Description (after Johnston and Mawson, 1940). Buccal capsule with spiral thickenings not laterally flattened, 0.070 mm long and 0.070 mm wide in the middle, its walls very thick, its margins with six lobes.

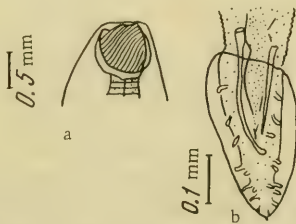


FIGURE 122. *Spirocamallanus murrayensis* (Johnston and Mawson, 1940):

a — cephalic end; b — caudal end of male (after Johnston and Mawson, 1940).

Male. Length 4–5 mm, maximum width 0.13 mm. Muscular anterior part of esophagus ending 0.4 mm from the cephalic end, glandular posterior part ending 0.9 mm from this end. Both parts more or less curved anteriorly. Nerve ring situated 0.2 mm from cephalic end. Caudal wings united anteriorly,

0.33 mm long. Three pairs of pedunculate preanal papillae, 2 pairs post-anal, and 2 pairs of sessile papillae adanal. Spicules 0.29 and 0.20 mm long, simple, pointed. Tail 0.15 mm long.

Female. Length 8–10 mm, maximum width 0.25–0.30 mm. Vulva forming a transverse slit before middle of body; branches of uterus opposite. Tail 0.1 mm long, its narrow distal part 0.030 mm long and 0.010 mm wide.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 33; Johnston and Mawson, 1940, p. 347; Yamaguti, 1961b, p. 45.

Spirocamallanus olseni Campana-Rouget and Razarihelissoa, 1965
(Figure 123)

Hosts: *Echeneis naucrates*, *Lutjanus duodecimlineatus*, *Lutjanus* sp.

Localization: stomach.

Distribution: Madagascar.

Description (after Campana-Rouget and Razarihelissoa, 1965). Small nematodes, tapering slightly at both ends. Buccal capsule oblong, with thickened walls, inner surface with 8 or 9 spiral ribs; capsule 0.085–0.095 mm long and 0.062–0.072 mm wide. Mouth rounded, its inner diameter as long as the width of the buccal capsule; 4 submedian papillae in the outer ring and 2 distinct amphids laterally. Buccal capsule surrounded by 8 longitudinal muscle stripes with equal intervals. Anterior part of esophagus club-shaped, muscular, posterior part slightly longer, glandular. Nerve ring situated in middle of first part of esophagus, deirids slightly before it, excretory pore slightly behind it, near the connection of the two parts of the esophagus.

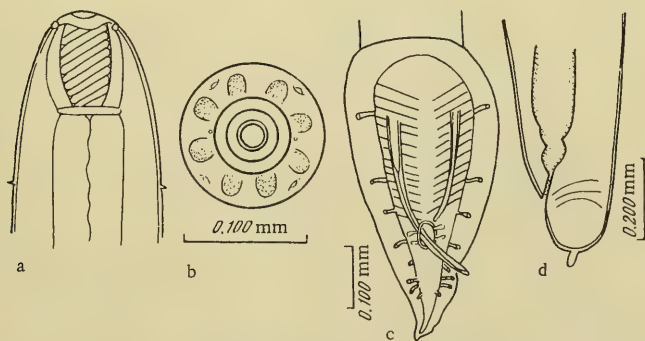


FIGURE 123. *Spirocamallanus olseni* Campana-Rouget and Razarihelissoa, 1965:

a — cephalic end, dorsoventral; b — same, apical; c — caudal end of male, ventral; d — caudal end of female, lateral (after Campana-Rouget and Razarihelissoa, 1965).

Male. Length 9–15 mm, width 0.25 mm. Nerve ring situated 0.280 mm, 204 deirids 0.140 mm, excretory pore 0.390 mm from cephalic end. Muscular part of esophagus 0.38 mm long, glandular part 0.56 mm. Right spicule thick, gutter-shaped, 0.330–0.380 mm long; left spicule thinner and less strongly chitinized, 0.180–0.220 mm long. Caudal wings well developed, united anteriorly on the ventral surface, where the body wall is strengthened by oblique muscles. All papillae pedunculate, 8 pairs: 3 pairs preanal, one pair adanal, and 4 pairs postanal; their arrangement varies slightly in different specimens and is often asymmetrical, and the last pair, which is situated more ventrally than the preceding pair, is sometimes situated at the same level as this, posteriorly. Two pairs of teatlike, chitinized, finger-shaped formations at the cloaca.

Female. Length 12–20 mm, width 0.5 mm. Nerve ring situated 0.285 mm, deirids 0.175 mm, excretory pore 0.615 mm from the cephalic end. Muscular part of esophagus 0.55 mm long, glandular part 0.72 mm. Tail round, slightly tapering, with a finger-shaped appendage 0.040–0.042 mm long and with two small spines.

In a specimen 14.5 mm long, the vulva is situated in the middle of the body, in other, larger individuals it is situated slightly behind the middle and in smaller specimens (12 mm) before the middle; the vulva is displaced therefore further posteriorly in the larger specimens. It protrudes weakly. Vagina directed posteriorly, branches of uterus opposite, distended, with thin wall, containing eggs and larvae.

Reference: Campana-Rouget and Razarihelissoa, 1965, pp. 171–176.

Spirocamallanus ophiocephalus (Ali, 1960) (Figure 124)

Synonym: *Procamallanus ophiocephalus* Ali, 1960

Host: *Ophiocephalus punctatus*.

Localization: gills (?).

Distribution: India.

Description (after Ali, 1960).

Male. Body thin, cylindrical, narrowing posteriorly and ending in a pointed tail. Cephalic end widened at the buccal capsule. Cuticle 0.037 mm thick in middle of body, transversely striated with intervals of 0.011 mm. Length 5.8 mm, width 0.19 mm. Dorsoventral width of cephalic end 0.13 mm. Excretory pore situated 0.33 mm, nerve ring 0.24 mm from cephalic end. Buccal capsule spherical, with sickle-shaped formations with "manubria" arranged obliquely at the base; "cutting edges" form the margins of the capsule, their sharp ends contiguous immediately below the amphids. Five to 7 transverse ribs in the buccal capsule. Four cephalic papillae. Esophagus 1.67 mm long, $1/4$ of length of body, divided into two parts 0.66 and 1.01 mm long.

Tail conical, with wide, symmetrical caudal wings 0.48 mm long and 0.26 mm wide. Eight pairs of riblike preanal papillae forming two groups of four. Postanal papillae also forming two groups. The first group consists of 4 pairs situated close together; a fifth pair is displaced to the 205 end of the tail. Two pairs of papillae situated around the cloaca: one pair

slightly before and one pair slightly behind it. Spicules of different length and form. Right spicule 5 times as long as the left, 0.15 mm long. Left spicule 0.034 mm long. Right spicule with wide, rectangular anterior end and pointed posterior end. Left spicule wider in the middle, with narrow anterior end and inward-curved posterior end. Tail 0.2 mm long.

Female unknown.

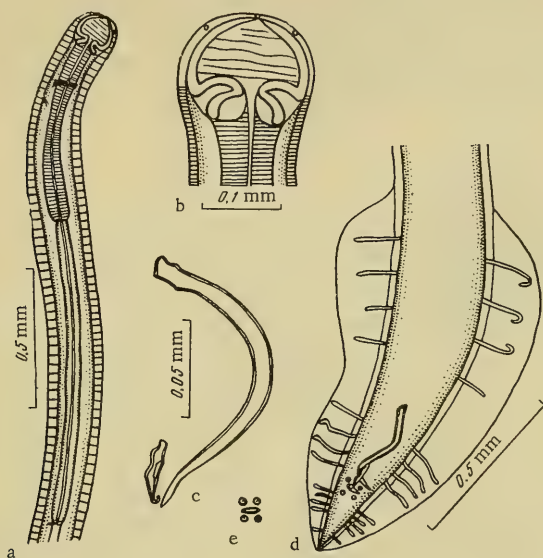


FIGURE 124. *Spirocamallanus ophioccephalus* (Ali, 1960):

a — anterior end, lateral; b — cephalic end, lateral; c — spicules; d — posterior end of male, ventral; e — arrangement of papillae around the cloaca in the male (after Ali, 1960).

Reference: Ali, 1960, pp.132—134.

Spirocamallanus parasiluri (Fujita, 1927) Olsen, 1952
(Figure 125)

Synonym: *Procamallanus parasiluri* Fujita, 1927

Host: *Parasilurus asotus*.

Localization: intestine.

Distribution: Japan.

Description (after Fujita, 1927). Description based only on females. Body uniformly thin, tapering from the anus and ending in three small spines. Length 6 mm, width in the middle 0.14 mm. Except in the cephalic region, the cuticle is about 0.014 mm thick, with fine transverse striation with intervals of 0.004 mm. Buccal capsule formed by dark brown valves, truncate anteriorly and narrowing posteriorly. A wide, thick ring at the posterior end of the capsule. Outer surface of buccal capsule smooth, inner surface with

oblique parallel striation. Capsule 0.12 mm long and 0.07 mm wide. Tridents absent. Esophagus 0.43 mm long and 0.05 mm wide, its anterior part muscular. Intestine 4.68 mm long and 0.05 mm wide. Nerve ring situated 0.19 mm, excretory pore 0.16 mm from the cephalic end. Vulva situated 5.0 mm from the cephalic end, i. e. at more than $2/3$ of the body. One ovary, 1.45 mm long and 0.046 mm wide, situated in anterior half of body, extending anteriorly to 2.5 mm from the cephalic end. Uterus double: anterior part 1.11 mm long, larger than the posterior part, which is 0.65 mm long and extends posteriorly almost to the anus. Vagina with thick wall, 0.41 mm long, directed obliquely posteriorly. All specimens were young, without ripe eggs. Tail 0.12 mm long.

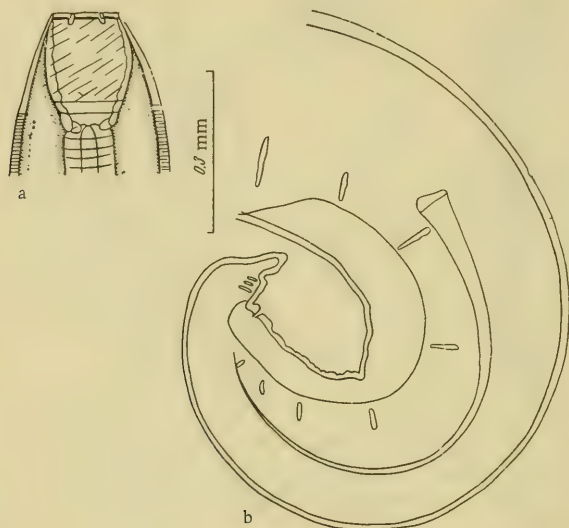


FIGURE 125. *Spirocamallanus parasiluri* (Fujita, 1927):

a — buccal capsule; b — caudal end of male, lateral (a — after Fujita, 1927; b — after Yamaguti, 1935).

Description (after Yamaguti, 1935). Yamaguti found four mature females and one immature male of this species and gave a brief description and a drawing of the caudal end of the male. Mouth wide, with membranous margin which is supported by regularly spaced spines in grooves on the thickened anterior margin of the buccal capsule, and with delicate muscle fibers attached to the spines which extend across the smooth outer surface of the capsule posteriorly. Inner surface of buccal capsule with continuous 207 spiral ribs. Cuticle to 0.030 mm thick at the nerve ring, which is situated 0.23–0.25 mm from the cephalic end.

Male. Length 4.44 mm, width 0.11 mm. Buccal capsule 0.090 mm long and 0.075 mm wide. Muscular anterior part of esophagus 0.35 mm long and 0.05 mm wide, posterior glandular part 0.338 mm long and 0.05 mm wide. Yamaguti found only one spicule in the form of an elongate horn. The subventral caudal wings do not project much. Eight pairs of caudal papillae, the preanal

papillae long and pedunculate, with intervals which decrease posteriorly; the three pairs of postanal papillae are similar, situated close together.

Female. Length 12.3 mm. Buccal capsule 0.108—0.114 mm long and 0.090—0.096 mm wide. Muscular anterior part of esophagus 0.475—0.51 mm long and 0.06—0.08 mm wide, glandular posterior part 0.51—0.6 mm long and 0.050—0.070 mm wide. Vulva without protruding lips, situated at about 1/5 of the length of the body from the caudal end. Eggs almost round, 0.024—0.027 mm wide; eggs segmented, without developed larvae.

References: Skrzjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 33; Fujita, 1927, pp. 169—176; Yamaguti, 1935, pp. 347—386.

Spirocamallanus pereirai (Annereaux, 1946) Olsen, 1952 (Figure 126)

Synonym: *Procamallanus pereirai* Annereaux, 1946

Hosts: *Micropodon undulatus*, *Leptocottus armatus*, *Gillichthys mirabilis*, *Fundulus parvipinnis*, *Girella nigricans*, *Atherinops affinis*.

Localization: intestine.

Distribution: USA.

Historical review

The description of *Procamallanus pereirai* (Annereaux, 1946) is the first record of the genus in North America. Sogandares-Bernal (1955) found *P. pereirai* in *Micropodon* (Sciaenidae). The parasite was originally found not in Perciformes but in *Atherinops*, which belongs to the Mugilidae.

Noble and King (1959) found the species in *Gillichthys mirabilis*. They gave a description of *P. pereirai* and the drawings are reproduced here. They found that 800 out of 810 fish examined were infected with the parasite. Young specimens were usually localized in the anterior part of the intestine, larger specimens in the posterior part. All nematodes were attached to the mucosa by the buccal capsule. If there was food in the intestine, the nematodes concentrated around it. (Noble and King, 1959, pp. 681—683.)

Noble and King (1959) found *P. pereirai* also in the following hosts: *Leptocottus armatus* (Cottidae), *Atherinops affinis* and *Fundulus parvipinnis* (Mugiliformes), and *Girella nigricans* (Perciformes). The infection rate of these hosts was high. The average number of specimens of *P. pereirai* was proportional to the size of the fish. The salinity of the water had no effect on the infection.

Description (after Annereaux, 1946). Reddish in life. Body thin, narrower at both ends. Cephalic end truncate, mouth rounded, terminal. Buccal capsule barrel-shaped, with 14 continuous spiral thickenings in both sexes. Cuticle thick, finely transversely striated in the cephalic region; striation coarser in posterior part of body.

Male. Length 6.8 mm, width 0.189 mm. Posterior end slightly curved ventrally. Buccal capsule 0.07 mm long and 0.06 mm wide. Muscular part of esophagus 0.33 mm long, glandular part 0.43 mm. Caudal wings symmetrical, connected ventrally 0.357 mm from end of tail, supported by 9 pairs

of riblike papillae, 3 pairs preanal and 6 pairs postanal. Spicules of similar form but of different length: right spicule 0.43 mm long, left spicule 0.21 mm. Tail 0.138 mm long, with two small, rounded processes at the end.

(208)

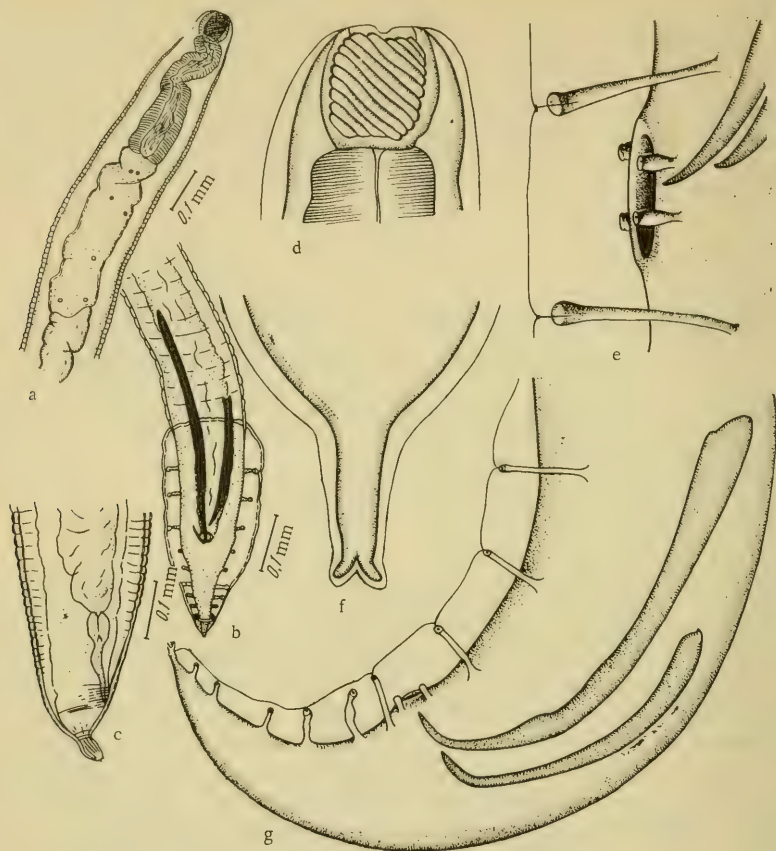


FIGURE 126. *Spirocamallanus pereirai* (Annereaux, 1946):

a — anterior end; b — caudal end of male, ventral; c — caudal end of female, lateral; d — buccal capsule; e — cloaca of male, lateral; f — end of tail of female; g — caudal end of male, lateral (a—c — after Annereaux, 1946; d—g — after Noble and King, 1959).

Female. Length 8.73–10.00 mm, width 0.232–0.258 mm. Length of buccal capsule 0.080–0.086 mm, width 0.07–0.08 mm. Muscular part of esophagus 0.39 mm, glandular part 0.51–0.53 mm. Excretory pore situated about 0.40 mm from the cephalic end. Vulva situated slightly behind middle of body. Tail tapering, constricted at the anus and ending in a finger-shaped process which is directed ventrally, with short terminal spines. Uterus containing eggs at different stages of development, but no larvae.

Description (after Noble and King, 1959). Red in life, intestine blackish red.

Male (25 specimens examined). Length 10.80–17.65 mm, width 0.125–0.280 mm. Length of buccal capsule 0.052–0.079 mm, width 0.048–0.076 mm. Muscular part of esophagus 0.280–0.500 mm long, glandular part 0.400–0.775 mm.

Caudal end with symmetrical wings. Nine pairs of caudal papillae, 3 pairs preanal and 6 pairs postanal. All papillae with flattened apex, from which extend threadlike formations, which apparently connect them with the wings. Two pairs of small modified papillae, situated at the cloaca. These papillae were not mentioned by Annereaux. Spicules of similar form but of different length: right spicule about 0.43 mm long, left spicule 0.20 mm. Tail with two small, kidneylike appendages at the end.

Female (25 specimens examined). Length 13.85–26.30 mm, width 0.235–0.460 mm. Length of buccal capsule 0.058–0.083 mm, width 0.052–0.075 mm. Muscular part of esophagus 0.350–0.525 mm long, glandular part 0.525–0.897 mm.

Vulva usually situated slightly behind middle of body. Uterus usually filled with eggs and embryos. Posterior end pointed and narrowing behind the anus with a narrow ventral finger-shaped process, which ends in two small terminal appendages like those in the male.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 33; Annereaux, 1946, pp. 299–303; Noble and King, 1959, pp. 679–685; Sogandares-Bernal, 1955, pp. 587–594; Yamaguti, 1961b, p. 45.

Spirocamallanus rarus (Travassos, Artigas, and Pereira, 1928)
Olsen 1952 (Figure 127)

Synonym: *Procamallanus rarus* Travassos, Artigas, and Pereira, 1928

(210)

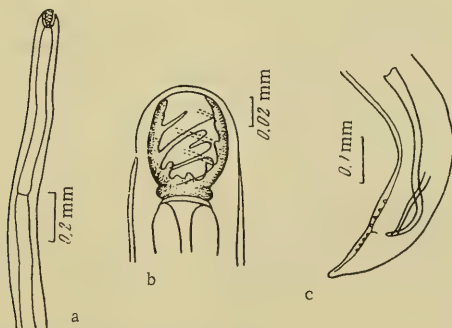


FIGURE 127. *Spirocamallanus rarus* (Travassos, Artigas, and Pereira, 1928):
a — anterior end of male; b — cephalic end of male; c — caudal end of male (after Travassos, Artigas, and Pereira, 1928).

Hosts: *Pimelodella lateristriga*, *Rhynodoras dorbignyi*.

Localization: intestine.

Distribution: Brazil.

210 Description (after Travassos, Artigas, and Pereira, 1928).

Male (one specimen). Length 5.3 mm, width 0.11 mm. Excretory pore situated about 0.38 mm, nerve ring 0.25 mm from the cephalic end. Buccal capsule wide, with 3-4 spiral ribs which project markedly; length of capsule 0.072 mm, maximum width 0.056 mm. Muscular part of esophagus separated from the capsule by a chitinated ring, about 0.68 mm long, 0.04 mm wide; glandular part cylindrical, 0.64 mm long and 0.048 mm wide. Caudal end with narrow wings and 8 pairs of papillae, 4 pairs preanal and 4 pairs postanal. Spicules 0.4 and 0.17 mm long. Tail 0.12 mm long, conical.

Female unknown.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 33; Travassos, Artigas, and Pereira, 1928, pp. 5-68.

Spirocamallanus singhi (Ali, 1956) Olsen, 1952 (Figure 128)

Synonym: *Procamallanus singhi* Ali, 1956

Host: *Callichrous bimaculatus*.

Localization: stomach.

Distribution: India.

Description (after Ali, 1956). Reddish in life. Cuticle transversely striated with intervals of 0.005 mm. Mouth oval. Cephalic end with 2 pairs of submedian papillae and a pair of lateral amphids. Esophagus divided into two parts. Body cylindrical, narrower anteriorly; tail short, pointed in both sexes. Buccal capsule with double spiral thickenings.

Male. Length 5.9-6.68 mm, thickness 0.133-0.143 mm. Excretory pore situated 0.31 mm, nerve ring 0.105-0.107 mm from the cephalic end. Buccal capsule 0.059-0.065 mm long and 0.053-0.059 mm wide. Length of esophagus 0.68-0.71 mm, i. e. $1/8$ of length of body. Muscular part of esophagus 0.305-0.316 mm long, glandular part 0.38-0.40 mm. The coiled, single testis is situated in the esophageal region. It passes in the middle of the body into the vas deferens, which has the same width, and then into the seminal vesicle, which passes into the ejaculatory duct. Caudal end narrowing before the cloaca. Caudal wings 0.39-0.41 mm long. Eleven pairs of caudal papillae, 7 pairs preanal and 4 pairs postanal. Lateral cuticular processes present. Spicules of different length and form: right spicule 0.200-0.205 mm long, left spicule 0.042-0.044 mm. The short spicule is widened in the middle, then becomes narrower and then widens again. The long spicule is almost of the same width throughout, with pointed distal end and slightly widened proximally. Tail 0.049-0.052 mm long.

Female. Length 6.152-6.92 mm, width 0.166-0.170 mm. Excretory pore situated 0.45 mm, nerve ring 0.168-0.180 mm from the cephalic end.

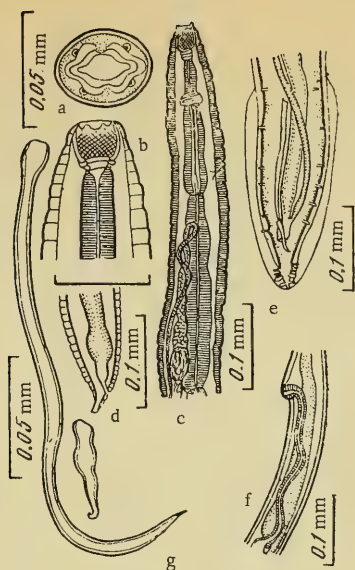


FIGURE 128. *Spirocamallanus singhi* (Ali, 1956):

a — cephalic end, apical; b — same, lateral; c — anterior end of female, lateral; d — posterior end of female, lateral; e — posterior end of male, ventral; f — region of vulva, lateral; g — spicules (after Ali, 1956).

Buccal capsule 0.076–0.083 mm long and 0.059–0.066 mm wide. Length of esophagus 1.05–1.12 mm, i. e. 1/6 of length of body. Muscular part of esophagus 0.44–0.48 mm long, glandular part 0.61–0.64 mm.

Oviduct narrow, ovary threadlike, forming a loop and extending anteriorly to the esophagus. Seminal vesicle swollen. Uterus extending posteriorly; vagina also connected with the blind opposite uterine sac. Vagina about 2.85–3.3 mm long, slightly sinuous, vulva protruding, with distinct lips. Tail 0.025 mm long, conical, with two small processes at the end.

References: Ali, 1956, pp.9–11; Yamaguti, 1961b, p.46.

212 *Spirocamallanus tornquisti* (Baylis, 1923) Campana-Rouget, 1961 (Figure 129)

Synonym: *Procamallanus spiralis* Baylis, 1923 sensu Tornquist, 1931

Hosts: Sparidae — *Crenideus joraklii*, *Sargus nort*; Labridae — *Cheilinus trilobatus*; Soleidae — *Achinus* sp.; Sciaenidae.

Localization: stomach and intestine.

Distribution: Red Sea, Gulf of Suez, Gulf of Mexico, Pacific coast of Mexico.

Historical review

Campana-Rouget (1961a) noted discrepancies between the description of *Procamallanus spiralis* of Tornquist (1931) and that of Baylis: the buccal capsule contains 9 spiral ribs instead of 12, the proportions of the two parts of the esophagus are different, and the males are markedly larger; she therefore suggested that Tornquist's specimens are a different species and named them *Spirocamallanus tornquisti*. Campana-Rouget stated that the number of species of *Spirocamallanus* parasitizing in marine fishes is very small compared with the number in freshwater fishes, and that it is unlikely that the same species would be found in hosts with a different biology. She is therefore of the opinion that Winter's specimens (1953) from Mexican fish are also *S. tornquisti*.

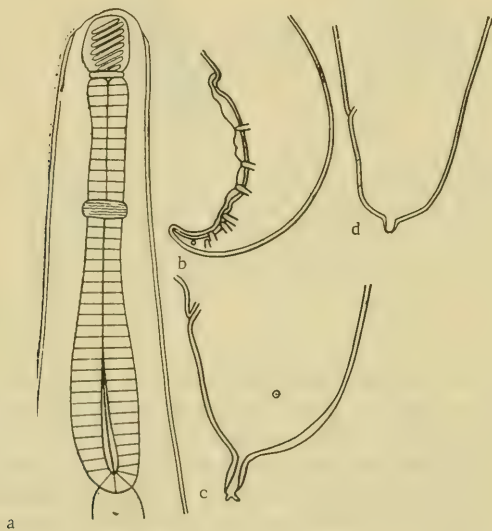


FIGURE 129. *Spirocamallanus tornquisti* (Baylis, 1923):

a — anterior end; b — caudal end of male, lateral; c, d — caudal end of female, lateral (after Tornquist, 1931).

Description (after Tornquist, 1931). Inner surface of buccal capsule with spiral ridges, outer surface with longitudinal ridges. Excretory system of the type "P".

Male. Length 10.924–13.505 mm. Nerve ring situated 0.172–0.234 mm from the cephalic end. Posterior part of esophagus 0.561–0.672 mm long, maximum width 0.156–0.234 mm. Tail 0.062 mm long. Buccal capsule 0.062–0.094 mm long.

Female. Length 13.026–27.160 mm. Length of buccal capsule 0.078–0.094 mm. Nerve ring situated 0.250–0.265 mm from the cephalic end. Length of posterior part of esophagus 0.561–0.655 mm. Vulva situated 5.507–12.48 mm from anterior end. Tail 0.172–0.187 mm long.

213 Description (after Winter, 1953).

Male not described.

Female. Red in life. Length 17.930–21.663 mm, maximum width 0.232–0.564 mm. Cephalic end with 6 weakly projecting lobes. Two pairs of cephalic papillae and 2 amphids. Mouth rounded. Cuticle with distinct transverse striation at the ends of the body, without striation in the middle. Tail conical, truncate, with a narrow process with two small teatlike appendages.

Buccal capsule barrel-shaped, 0.076–0.106 mm long and 0.068–0.087 mm wide. Its amber-colored lining has a spiral thickening with 9 turns. At the base of the capsule is a ring before the esophagus. Club-shaped anterior part of esophagus 0.498–0.664 mm long and 0.065–0.106 mm wide. Glandular posterior part also club-shaped, 0.566–0.863 mm long and 0.061–0.114 mm wide. It projects into the intestine with a short valve apparatus. Intestine 0.053–0.103 mm wide. Anus situated 0.082–0.217 mm from posterior end. There is a distinct musculature in the region of the anus.

Nerve ring situated in the posterior part of the glandular part of the esophagus, 0.274–0.361 mm from the cephalic end. Cervical papillae small, situated 0.144–0.152 mm, excretory pore 0.304–0.329 mm from the cephalic end.

Vulva situated in middle of body, 8.964–9.960 mm from posterior end. Vagina directed posteriorly, the part near the vulva with thick muscular walls; vagina 0.057–0.076 mm long, extending posteriorly for 0.498–1.240 mm. Uterus filling the greater part of the body cavity, containing embryos 0.399 mm long and 0.015–0.019 mm wide.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 34; Campana-Rouget, 1961a, pp. 24–25; Tornquist, 1931, p. 400; Winter, 1953, pp. 137–139; Yamaguti, 1961b, p. 46.

Spirocamallanus vachai Sinha and Sahay, 1965
(Figure 130)

Host: *Eutropiichthys vacha*.

Localization: intestine.

Distribution: India.

Description (after Sinha and Sahay, 1965). Small nematodes, blood-red in life. Cuticle thick, with fine transverse striation. Buccal capsule chitinized, without teeth, tridents, or papillae; it contains two systems of obliquely intersecting spiral thickenings. Esophagus divided into a club-shaped muscular anterior part and a longer glandular posterior part; ratio of length of these parts 1:1.5.

214 Male. Length 4.64–7.308 mm, maximum width 0.05–0.084 mm. Length of buccal capsule 0.4–0.05 mm, width 0.042 mm. Muscular part of esophagus 0.34–0.40 mm long, glandular part 0.42–0.52 mm. Nerve ring situated 0.124–0.148 mm from the cephalic end. Tail conical, 0.04–0.042 mm long, curved ventrally, with wings. Six pairs of preanal and 5 pairs of postanal pedunculate papillae; a winglike cuticular process on each side of the body behind the last postanal pair of papillae. Spicules weakly chitinized, bifid proximally, distal end pointed. Right spicule 0.182 mm long, left spicule 0.056 mm.

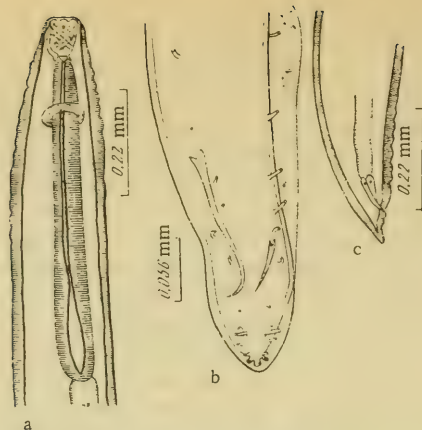


FIGURE 130. *Spirocamallanus vachai* Sinha and Sahay, 1965:

a — anterior end; b — caudal end of male, ventral; c — caudal end of female, lateral (after Sinha and Sahay, 1965).

Female. Length 8.9–12.72 mm, width 0.1–0.164 mm. Length of buccal capsule 0.056–0.064 mm, width 0.046–0.056 mm. Muscular part of esophagus 0.45–0.52 mm long, glandular part 0.58–0.72 mm. Nerve ring situated 0.12–0.14 mm from the cephalic end. Tail conical, 0.2 mm long, without papillae, ending in two short processes. Vulva situated behind middle of body, 3.28–3.68 mm from end of tail; vagina muscular and sinuous. Viviparous.

Reference: Sinha and Sahay, 1965, pp. 49–53.

Spirocamallanus viviparus (Ali, 1956) Olsen, 1952 (Figure 131)

Synonym: *Procamallanus viviparus* Ali, 1956

Host: *Mystus microphthalmus*.

Localization: stomach.

Distribution: India.

Description (after Ali, 1956). Reddish in life. Cuticle thick, transversely striated with intervals of 0.005 mm in middle of body. Body narrowing anteriorly and posteriorly. Two submedian pairs of cephalic papillae and 2 lateral amphids. Buccal capsule barrel-shaped.

215 **Male.** Length 2.3–3.19 mm, maximum width 0.083–0.092 mm. Nerve ring surrounding muscular part of esophagus 0.098–0.110 mm from the cephalic end. Excretory pore situated 0.26 mm from the cephalic end. Buccal capsule 0.051–0.082 mm long and 0.047–0.048 mm wide. Anterior part of esophagus 0.20–0.23 mm long, posterior part 0.25–0.29 mm. Length of esophagus 0.45–0.52 mm, i. e. about 1/6 of length of body. Testis thread-like, extending to the anterior end of the intestine. Caudal wings wide anteriorly, narrower posteriorly. Spicules of different length and form, right spicule 0.186 mm long, left spicule 0.069 mm. Ratio of length of spicules = 3:1. Right spicule with wide proximal part, curved inward at the

distal end. Left spicule slightly widened in the middle and curved like a hook at the distal end. Caudal wings 0.47 mm long and 0.15 mm wide, their anterior border passing across the ventral surface. Ten pairs of caudal papillae, 6 pairs preanal and 4 pairs postanal. Cuticular processes present between the third and last postanal pair of papillae. Tail 0.043–0.054 mm long.

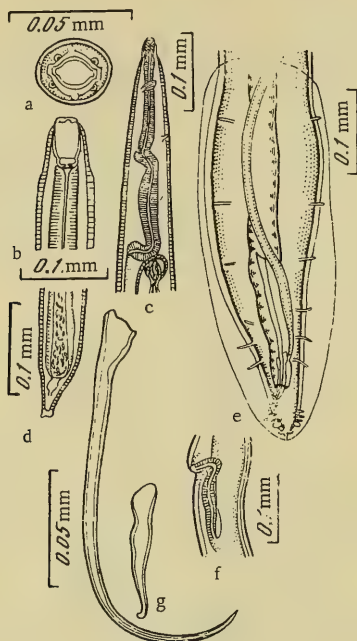


FIGURE 131. *Spirocamallanus viviparus* (Ali, 1956):

a — cephalic end, apical; b — same, lateral; c — anterior end of female, lateral; d — posterior end of female, lateral; e — posterior end of male, ventral; f — region of vulva, lateral; g — spicules (after Ali, 1956).

Female. Length 4.98–5.27 mm, maximum width 0.183–0.211 mm. Nerve ring situated 0.133–0.138 mm, excretory pore 0.29 mm from the cephalic end. Tail with three small processes at the end. Buccal capsule 0.059–0.061 mm long and 0.054–0.057 mm wide. Muscular anterior part of esophagus 0.29–0.31 mm long, glandular posterior part 0.41–0.43 mm. Length of esophagus 0.70–0.74 mm, about 1/7 of length of body. One ovary, extending anteriorly to the anterior third of the body. The oviduct surrounds the intestine, and passes into the seminal vesicle at the connection between esophagus and intestine. Vulva situated between third and last quarter of body. The posterior blind branch of the uterus extends to the anus. Vagina to 0.35 mm long. Vulva with protruding lips. Tail 0.038 mm long.

References: Ali, 1956, pp.13–15; Yamaguti, 1961b, p.46.

216 *Spirocamallanus wrighti* (Pereira, 1935) Olsen, 1952
(Figure 132)

Synonym: *Procamallanus wrighti* Pereira, 1935

Hosts: *Astyanax* sp., *Hoplias malabaricus*, *Leporinus* sp., *Pygocentrus* sp.

Localization: small intestine.

Distribution: Brazil.

Description (after Pereira, 1935). Small, reddish nematodes.

Male. Length 3.86–4.6 mm, width 0.18–0.27 mm. Cuticle with fine transverse striation. Mouth rounded. Buccal capsule large, spherical. Its walls with 12–16 chitinized ribs which are wide at the base, becoming narrower anteriorly and to the right, ending before the margin of the mouth. Width of buccal capsule 0.04–0.06 mm. Muscular part of esophagus club-shaped, 0.27–0.34 mm long, maximum width 0.08 mm; between esophagus and buccal capsule is a chitinized ring 0.008 mm high. Glandular part of esophagus about 0.47 mm long. Nerve ring situated 0.18 mm, excretory pore 0.17–0.18 mm from the cephalic end.

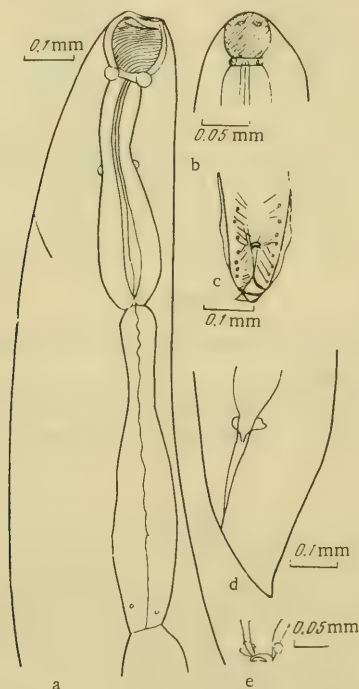


FIGURE 132. *Spirocamallanus wrighti* (Pereira, 1935):

a — anterior end, lateral; b — cephalic end, lateral; c — caudal end of male, ventral; d — caudal end of female, lateral; e — distal end of spicules (after Pereira, 1935).

Tail curved ventrally, with caudal wings which begin 0.25 mm from end of tail; anus situated 0.13–0.15 mm from end of tail.

Spicules short, weakly chitinized, about 0.045 mm long.

The ventral surface of the posterior end contains distinct oblique muscles. There are eight pairs of papillae in two subventral rows, 4 pairs preanal and 4 pairs postanal.

Female. Length 8.2–10.6 mm, width 0.30–0.38 mm. Cuticle with fine transverse striation. Buccal capsule 0.049–0.11 mm wide, with 20 chitinized ribs. Muscular part of esophagus 0.32–0.42 mm long, glandular part 0.5–0.70 mm. Nerve ring situated 0.25–0.29 mm, excretory pore 0.21–0.42 mm from the cephalic end. Anus situated 0.12–0.23 mm from the posterior end. Tail tapering. Vulva situated 3.4–4.5 mm from end of tail; branches of uterus diverging. Viviparous.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 34; Pereira, 1935, pp. 53–62.

Spirocamallanus xenopodis (Baylis, 1929) Olsen, 1952
(Figure 133)

Synonym: *Procamallanus xenopodis* Baylis, 1929

Host: *Xenopus muelleri*.

Localization: intestine (?).

Distribution: Africa.

Description (after Baylis, 1929b). Small nematodes. Buccal capsule barrel-shaped, its walls with irregularly interrupted ribs which form a spiral or are arranged diagonally. Striation of cuticle coarser in males than in females.

Male. Length 0.60–1.37 mm, maximum width 0.12–0.15 mm. Cuticular striation with intervals of 0.004 mm. Length of buccal capsule 0.08–0.10 mm. Muscular part of esophagus 0.26–0.30 mm long. Posterior end of glandular part of esophagus situated 0.46–0.50 mm from the cephalic end, nerve ring situated 0.13–0.15 mm from the cephalic end.

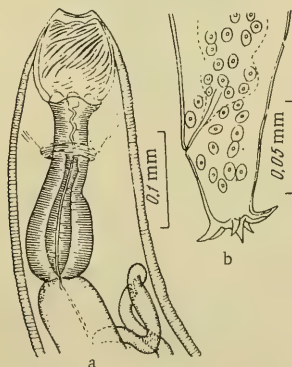


FIGURE 133. *Spirocamallanus xenopodis* (Baylis, 1929):

a — anterior end; b — caudal end of female, lateral (after Baylis, 1929b).

Nine pairs of preanal pedunculate papillae and 4 pairs of postanal papillae, the three anterior pairs with long peduncles and situated subventrally; the last pair, large and sessile, is lateral. Spicules of different length, left spicule shorter and markedly thicker than the right. Right spicule 0.10–0.11 mm long. Tail with blunt end, smooth, 0.03 mm long.

Female (immature). Length 0.74–0.78 mm, maximum width 0.09–0.10 mm. Length of buccal capsule 0.070–0.075 mm. Distance from cephalic end to end of muscular part of esophagus 0.22–0.24 mm, to end of glandular part 0.37–0.38 mm. Nerve ring situated 0.11–0.12 mm from the cephalic end. Vulva situated 0.31–0.41 mm from end of tail which bears 7 spines, one terminal and median, the other six forming a ring; the number of spines is constant. Tail 0.04–0.05 mm long.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 34; Baylis, 1929b, pp. 378–380; Yamaguti, 1961b, p. 113.

218 *Spirocamallanus* sp. Campana-Rouget, 1961 (Figure 134)

Host: *Synodontis schall*.

Localization not given.

Distribution: Africa.

Description (after Campana-Rouget, 1961a). Length of buccal capsule 0.09 mm, width 0.08 mm; capsule with 10 spiral ribs on the inner surface. Outer surface of capsule with 8 finger-shaped formations which begin at the base and end in about the middle of the capsule; they are weakly chitinized. Tornquist thinks that they form the outer layer of the buccal capsule.

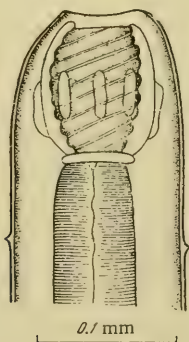


FIGURE 134. *Spirocamallanus* sp. Campana-Rouget, 1961.

Cephalic end (after Campana-Rouget, 1961a).

Length of muscular part of esophagus 0.51 mm, of glandular part 0.43 mm. Nerve ring situated 0.28–0.30 mm, deirids 0.174 mm from the cephalic end. In an immature female the vulva was situated 6.74 mm from the cephalic end.

Right spicule 0.170 mm long, left spicule 0.122 mm. Three pairs of preanal papillae, 4 or 5 pairs of postanal papillae, and 2 pairs of adanal papillae.

Reference: Campana-Rouget, 1961a, pp. 23–24.

SUPERFAMILY *ANGUILLICOLOIDEA* N. SUPERFAM.

Historical review

Sobolev (1952), in his classification of the suborder Camallanata, included the family Anguillicolidae Yamaguti, 1935 in the superfamily Dracunculoidea. Shigin and Shigina (1958) described the new species *Skrjabillanus tincae*, for which they established a new genus. This differs so markedly from all other genera of the family that the authors placed it in a separate family, *Skrjabillanidae*, which they considered related to the family Anguillicolidae.

Campana-Rouget (1964) considered the family Anguillicolidae as related to the family Tetanonematidae Skrjabin and Schikhobalova, 1948, which Skrjabin and Shikhobalova (1948) had established for the genus *Tetanonema* Steiner, 1937, in contrast to the author, who had placed the genus provisionally in the subfamily Aproctinae.

Yamaguti (1961b) placed the family Tetanonematidae in the order Tetanonematidea Yamaguti, 1961.

We think the families Anguillicolidae Yamaguti, 1935, Tetanonematidae Skrjabin and Schikhobalova, 1948, and *Skrjabillanidae* Schigin and Schigina, 1958 should be placed in a new superfamily which we name Anguillicoloidea Sobolev, Ivashkin, Tichomirova, and Khromova n. superfam. We also place the family Phlyctainophoridae Roman, 1960 provisionally in this superfamily.

Diagnosis. Camallanata. Body threadlike or cylindrical. Males smaller than females. Cephalic papillae present. Stoma developed or reduced. Esophagus well developed or reduced. Anus present or absent. Spicules and gubernaculum absent in males, or a chitinated plate is present. Caudal papillae present. Vulva present. Parasites of the connective tissue, body cavity, and blood sinuses of fish and Cyclostomata.

Type family: Anguillicolidae Yamaguti, 1935.

Key to the families of the superfamily Anguillicoloidea

- 1. Stoma developed 2.
Stoma reduced 3.
- 2. Caudal wings present in males. Vulva situated in anterior half of body *Skrjabillanidae* Schigin and Schigina, 1958.
Caudal wings absent. Vulva situated in posterior part of body
..... *Anguillicolidae* Yamaguti, 1935.
- 3. Body long, threadlike. Cuticle with more or less irregularly distributed tubercles in anterior part of body
..... *Tetanonematidae* Skrjabin and Schikhobalova, 1948.
Body cylindrical, curved ventrally. One row of symmetrical rounded processes on each side situated subdorsally, 15 processes in a row ..
..... *Phlyctainophoridae* Roman, 1960 .

219 FAMILY *ANGUILLICOLIDAE* YAMAGUTI, 1935

Diagnosis. Anguilliculoidea. Slender nematodes. Stoma developed. Esophagus consisting of a muscular anterior swelling and a cylindrical muscular-glandular posterior part. Anus absent. Male without spicules. Caudal papillae present. Vulva situated in posterior half of body. Viviparous.

Type genus: *Anguillicola* Yamaguti, 1935.

Genus *Anguillicola* Yamaguti, 1935

Diagnosis. Anguillicolidae. Buccal cavity wide. Esophagus divided into a muscular anterior swelling with three projecting lobes and a cylindrical muscular-glandular posterior part. The posterior end of the esophagus forms a glandular ventricle which projects into the intestine. Intestine swollen, dark. Caudal glandular cells project into the ejaculatory duct.

Male. Spicules absent. Testis beginning at the caudal end. Seminal vesicle distinct. Ejaculatory duct opening on a projecting papilla.

Female. Vulva situated in posterior half of body, on the apex of a projecting cone. Vagina short, surrounded by dense glandular cells. Branches of uterus opposite. Viviparous.

Parasites of the swim bladder of freshwater fishes.

Type species: *A. globiceps* Yamaguti, 1935.

Anguillicola globiceps Yamaguti, 1935 (Figure 135)

Host: *Anguilla japonica*.

Localization: swim bladder.

Distribution: Japan.

Description (after Yamaguti, 1935).

Male. Length 26 mm, width 0.8 mm. Length of buccal capsule 0.06 mm. 221 Anterior swelling of esophagus 0.38 mm wide. Nerve ring situated 0.5 mm from the cephalic end. Six pairs of caudal papillae.

Female. Length 60 mm, width 1.8 mm. Length of buccal capsule 0.1 mm. Anterior swelling of esophagus 0.7 mm wide. Nerve ring situated 0.6 mm from the cephalic end. Vulva situated about 5 times farther from the cephalic end than from end of tail. Larvae in uterus 0.28 mm long.

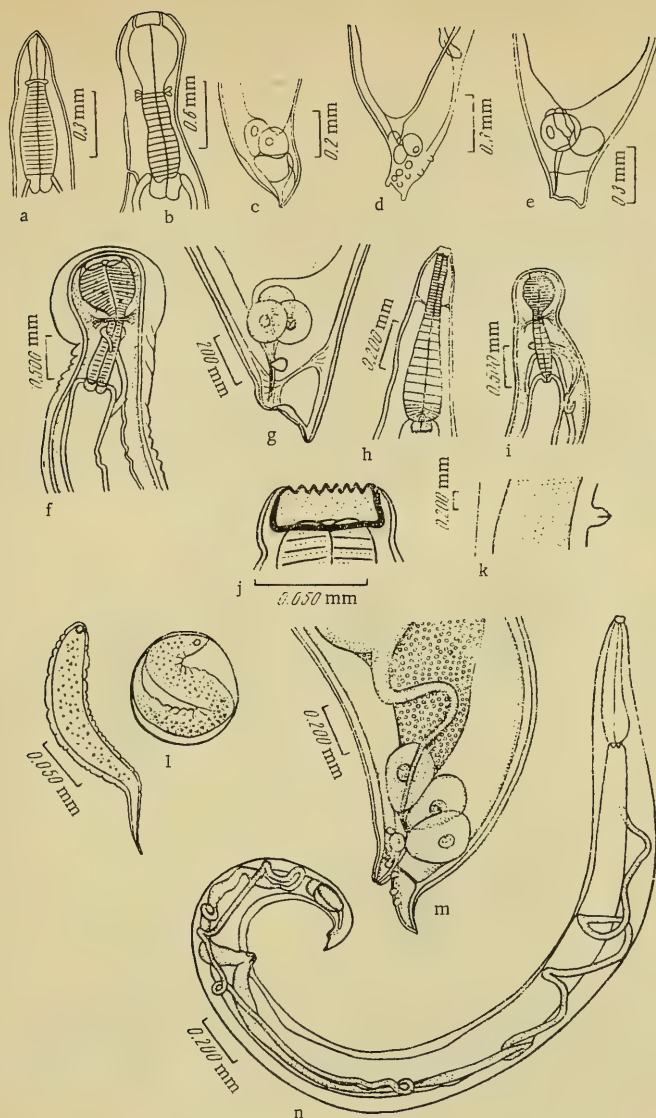


FIGURE 135. *Anguillicola globiceps* Yamaguti, 1935:

a, b — cephalic end, different aspects; c, d, e — caudal end; f, h, i — anterior end; g, m — caudal end; j — cephalic end; k — region of vulva; l — egg with larva and larva; n — female, general view (a–e — after Yamaguti, 1935; f–n — after Wu, 1956).

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 90; Yamaguti, 1935, pp. 347–386; 1961b, pp. 79–80; Wu, 1956, pp. 99–106.

Anguillicola australiensis Johnston and Mawson, 1940
(Figure 136)

Host: *Anguilla reinhartii*.

Localization: swim bladder.

Distribution: Australia.

Description (after Johnston and Mawson, 1940). Cephalic end bulb-shaped, neck distinctly constricted. Body tapering posteriorly, tail pointed. The anterior bulb-shaped widening is much wider dorsoventrally than laterally. Mouth with 6 small papillae; buccal cavity wider at the base than anteriorly, with toothed inner margin which appears like a crown of leaves. Ratio of length of esophagus to length of body 1:30; esophagus strongly muscular, widening proximally. At the anterior end of the esophagus are 6 lobes which project into the buccal cavity. Nerve ring situated behind the cephalic swelling. Excretory pore situated on an elevation near the posterior end of the esophagus. Intestine wide, with dark content; the dark intestinal contents are not visible at the posterior end, and the rectum is probably a narrow tube.

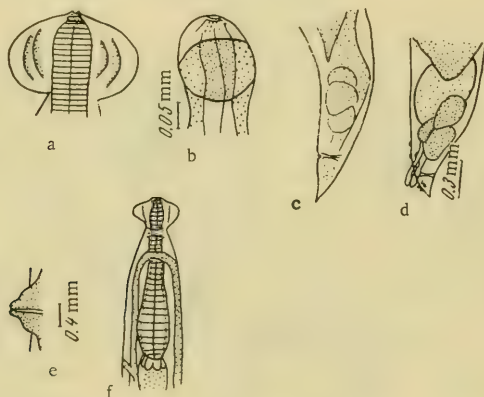


FIGURE 136. *Anguillicola australiensis* Johnston and Mawson, 1940:

a — cephalic end, lateral; b — same, ventral; c — caudal end of female;
d — caudal end of male, lateral; e — region of vulva; f — anterior end, lateral
(after Johnston and Mawson, 1940).

222 Male. Length 40 mm, width 1 mm. Two pairs of preanal and 2 pairs of postanal papillae. Spicules absent.

Female. Length 60–70 mm, width 1.5 mm (young females 25–30 mm long, 0.5 mm wide). In a specimen 25 mm long the swollen cephalic end is 0.14 mm long, 0.22 mm wide dorsoventrally, and 0.13 mm wide laterally. Length of buccal capsule 0.010 mm, width in the middle 0.028 mm. Esophagus 0.82 mm long. Nerve ring situated 0.18 mm from the cephalic end. An anus was not found in females, but 0.4 mm from the end of the tail in a specimen 25 mm long and at corresponding points in larger specimens there is a small incision before which are situated four large glandular masses; before these, 1.1 mm from end of tail, the dark intestinal content is not visible;

the rectum is probably a narrow tube. Vulva with protruding lips, situated on a round elevation which is situated $1/6$ of the length of the body from the posterior end. Ovaries extending into the anterior and caudal regions. Eggs with thin shell, $0.012-0.015 \times 0.025-0.026$ mm large.

Reference: Johnston and Mawson, 1940, p. 351.

222 FAMILY *PHLYCTAINOPHORIDAE* ROMAN, 1960

Historical review

Steiner (1921) described a unique nematode from a single female which he named *Phlyctainophora lamnae*. The form of the body was not described, as it was studied only from sections. Yorke and Maplestone (1926) considered the systematic position of this genus as uncertain, while Chitwood (1937) placed it in the subfamily Philometrinae. Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov (1954) also retained the genus in the subfamily Philometrinae, but Ruyck and Chabaud (1960) did not agree; they found larvae of this nematode on the fins of fish and because of their possible direct development, they assumed that the genus is closely related to the group of tissue Aphasmidia: *Muspicea* and *Robertdolfusa*. Roman (1960) established for this genus the family Phlyctainophoridae Roman, 1960, which she placed in the order Enoplida of the subclass Adenophorea.

Until a more detailed study is made of the species of this family, we place it provisionally in the superfamily Anguilliculoidea.

Diagnosis. Anguilliculoidea. Cuticle smooth, but with slight striation in some places. Intestine narrow compared with the size of the parasite. Uterus filled with embryos; vulva not found.

Adults and young forms parasitize in the tissue of fish.

Type genus: *Phlyctainophora* Steiner, 1921.

Genus *Phlyctainophora* Steiner, 1921

Diagnosis. Phlyctainophoridae. Body curved ventrally. A row of symmetrical rounded protuberances on each side, subdorsally 15 in a row. Anterior end with one such swelling, posterior end with two swellings. Cuticle smooth. Intestine narrow. Viviparous.

223 Parasites of Euselachiae.

Type species: *Phlyctainophora lamnae* Steiner, 1921.

Phlyctainophora lamnae Steiner, 1921 (Figure 137)

Hosts: *Lamna cornubica*, *Mustelus mustelus*.

Localization: between mandibular cartilage and skull.

Distribution: Atlantic Ocean (?).

Description (after Janicki and Rasin, 1930).

Male unknown.

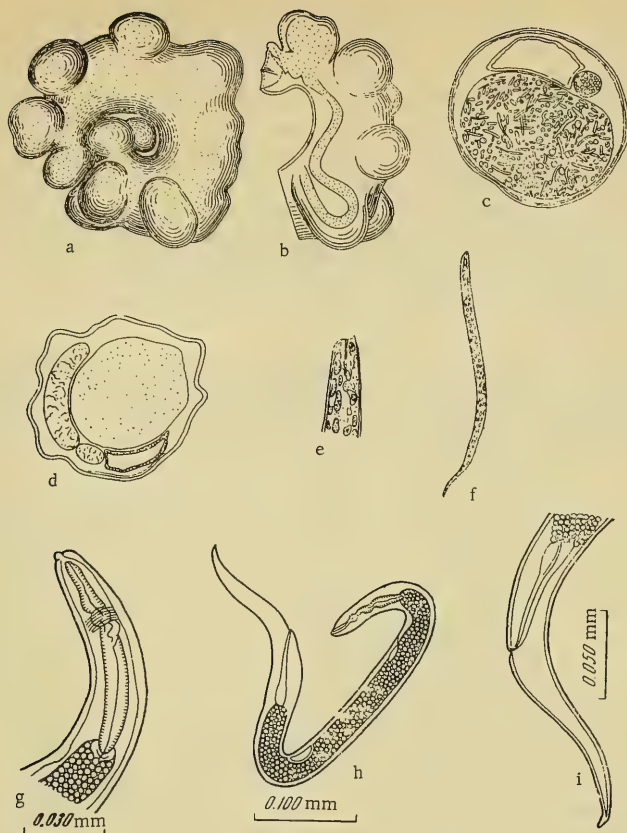


FIGURE 137. *Phlyctainophora lamnae* Steiner, 1921:

a — general view; b — anterior end; c, d — cross sections; e — anterior end of larva; f — larva; g — anterior end of larva; h — larva; i — caudal end of larva (a-f — after Steiner, 1921; g-i — after Ruyck and Chabaud, 1960).

224 Female. Length 17 mm. Body curved ventrally, consisting of a tube filled with embryos. On the outside are 15 round protuberances 0.009 mm wide situated dorsally and submedially. Musculature absent. The thin-walled intestine follows the curvature of the body. Mouth and anus not recognizable. Uterus large, filled with larvae. Larvae slender, with a tooth-like appendage at the cephalic end.

The life cycle has not been studied, but in 1960, Ruyck and Chabaud found and described larvae of nematodes which they identified as *Phlyctainophora lamnae* in swellings at the base of the ventral surface of the abdominal fins of *Mustelus mustelus*.

Description of larvae. Length 0.520–0.600 mm, width 0.030 mm. Cephalic end with a distinct dorsal tooth. A larva 0.600 mm long showed the following characters: esophagus cylindrical, widened posteriorly, 0.080 mm long. Nerve ring situated 0.030 mm, excretory pore 0.110 mm from the anterior end. The intestine occupied almost the whole body cavity. Rectum

0.070 mm long. Genital opening ventral, 0.025 mm long, situated 0.140 mm before the anus. Tail 0.120 mm long, tapering and with pointed end. Phas-
mids not found.

The general appearance of the larvae and the simple esophagus probably indicate that they live in the tissues and cannot survive in the outer environment; the large size of the larvae makes it impossible for them to be transmitted by hematophagous vectors. Their life cycle is therefore probably the same as in the tissue Aphasmodia, or perhaps as follows: An adult female, dying in the host, releases a large number of larvae which grow and disperse throughout the tissues. The body of such a shark infected with larvae may be eaten by other sharks, so that infection is probably transmitted by cannibalism.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 85; Janicki and Rasin, 1930, p. 33, Ruyck and Chabaud, 1960, pp. 386—389; Steiner, 1921, pp. 591—595.

FAMILY *SKRJABILLANIDAE* SCHIGIN AND
SCHIGINA, 1958

Historical review

The family Skrjabillanidae was established for the new genus and species *Skrjabillanus tinca* from *Tinca tinca*. Molnár (1966b) described two further species of the genus: *S. scardinii* and *S. erythrophthalmi* from *Scardinius erythrophthalmus* in Hungary. In 1966, during a study of the helminth fauna of fish in Czechoslovakia, Moravec (1968) found these three species in the typical hosts and made a comparative study of the morphology of the 3 species. He found that *S. erythrophthalmi* differs markedly from the other two species in the form of the cephalic end and type of buccal capsule, and considered that these differences justified the establishment of a new genus. He also noted that some characters of *S. erythrophthalmi* do not agree with the original diagnosis of the genus *Skrjabillanus* but were added by Molnar in 1966. Moravec therefore proposes
225 the new genus *Molnaria* for *erythrophthalmi*, with the type species *Molnaria erythrophthalmi*. He transferred *Philometra intestinalis* (Dogiel and Bychowsky, 1934) Moravec, 1968 and *Philometra leucisci* (Agapova, 1963) Moravec, 1968 to the genus *Molnaria*.

Tichomirova (1968—1969) (published here for the first time) made a detailed study of the morphology of *S. tincae* and *S. scardinii* and concluded that the buccal capsule of *S. tincae* differs markedly from that of *S. tincae*. The buccal capsule of *S. scardinii* is hexagonal, that of *S. tincae* is cup-shaped. The outer width of the capsule is 0.013 mm in *S. tincae*, 0.018 mm in *S. scardinii*. At the base of the capsule of *S. scardinii* there are 6 chitinous teeth (two teeth on each sector of the esophagus). The teeth are almost of the same size and have the form of a truncate pyramid. The buccal capsule of *S. tincae* does not have such chitinized formations. There are 4 tubercles (of the embedded type) at the cephalic end in *S. scardinii*, but such structures are absent in *S. tincae*. Males of *S. tincae* have 6 pairs of papillae at the caudal end, while in males of *S. scardinii* there are only 5 pairs of caudal papillae; a pair of sessile preanal papillae is absent. *S. scardinii* parasitizes in the serosa of the swim bladder and in the eyes; *S. tincae* is a parasite of the serosa of the kidneys.

Tichomirova decided therefore to establish the new genus *Agrachanus* for *S. scardinii* with the type species *A. scardinii* (Molnar, 1966) Tichomirova n. comb.

There are thus three genera in the family Skrjabillanidae: *Skrjabillanus* Schigin and Schigina, 1958; *Agrachanus* Tichomirova n. gen.; *Molnaria* Moravec, 1968.

Diagnosis. Anguilliculoidea. Body threadlike. Cephalic end with or without tubercles. Buccal capsule strongly or weakly developed. Esophagus muscular or muscular-glandular. Amphids very large. Males markedly smaller than females. Anus obliterated in adults. Caudal end of males with wings supported by pedunculate and sessile papillae. The sessile papillae are preanal and postanal or only postanal. Spicules and gubernaculum absent; a chitinous rod or chitinous plate is present. Genital opening situated on a strongly projecting genital papilla. Vulva situated in anterior part of body. Caudal end of females bluntly rounded and with three processes.

Type genus: *Skrjabillanus* Schigin and Schigina, 1958.

Key to the genera of the family *Skrjabillanidae* (after Tikhomirova)

1. Buccal capsule smooth, without chitinized teeth at the base
..... *Skrjabillanus* Schigin and Schigina, 1958.
Chitinized teeth present at the base of the buccal capsule 2.
2. Three chitinized teeth at the base of the buccal capsule
..... *Molnaria* Moravec, 1968.
Six chitinized teeth at the base of the buccal capsule
..... *Agrachanus* Tichomirova n. gen.

Genus *Skrjabillanus* Schigin and Schigina, 1958

Diagnosis. *Skrjabillanidae*. Threadlike nematodes with rounded anterior end and pointed posterior end. Cephalic end club-shaped. Buccal capsule cup-shaped. Intestine straight, ending blind before the posterior end. Amphids large, bean-shaped. Females more than twice as large as males. Males with 6 pairs of genital papillae, three pairs long, pedunculate, postanal. Sessile papillae both preanal and postanal. Genital opening situated on a markedly projecting papilla. A chitinized rod bent at a right angle projects partly outside. The vulva is obliterated in mature females; its rudiment is visible in the region of the esophagus. The greater part of the body cavity of the female is occupied by the large uterus, which is filled with larvae. Parasites of fish.

Type species: *Skrjabillanus tincae* Schigin and Schigina, 1958.

Skrjabillanus tincae Schigin and Schigina, 1958 (Figure 138)

Host: *Tinca tinca*.

Localization: under serosa of kidneys.

Distribution: USSR, Czechoslovakia.

Description (after Shigin and Shigina, 1958). Delicate, very thin, threadlike nematodes. Females more than twice as large as males. Males burst when placed in water. Cuticle delicately transversely striated with

intervals of 0.001–0.0012 mm; the cuticle of the anterior part of the body has ringlike girdles with intervals of 0.010–0.033 mm.

Cephalic end slightly club-shaped. Mouth rounded, buccal capsule cup-shaped with thick, chitinized walls. Esophagus consisting of a muscular and a muscular-glandular part; glandular tissue situated on the dorsal side of the esophagus. Cephalic papillae arranged in two rings; inner ring consisting of large amphids and paired (dorsal and ventral), weakly developed papillae; outer circle with 8 papillae arranged in pairs.

Male. Length 6.1–7.45 mm, maximum width 0.022–0.023 mm. Body widest in the middle and at the cephalic end. Mouth 0.005–0.006 mm wide. Inner width of buccal capsule 0.006–0.0065 mm, outer width 0.008–0.0085 mm. Length of buccal capsule 0.0045 mm. Esophagus 1.047 mm long; muscular anterior part 0.275 mm long; the other part of the esophagus contains glandular tissue on the dorsal side. Intestine ending blind, 0.547 mm from the caudal end.

(227)

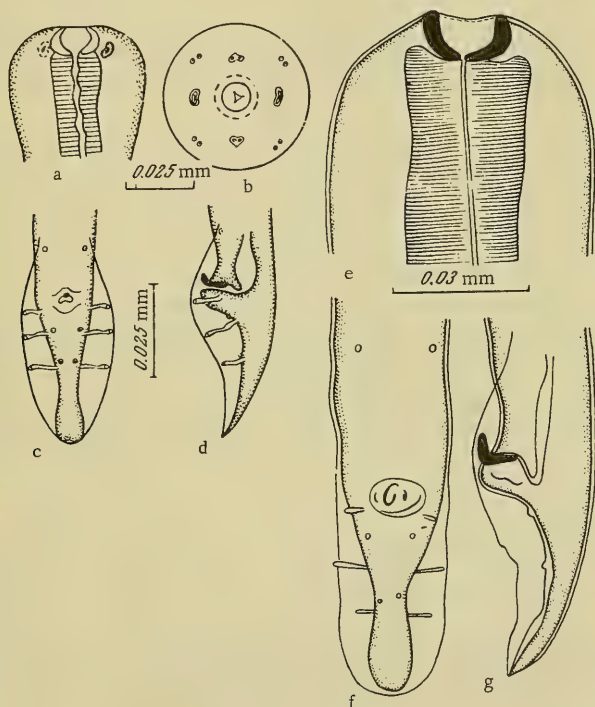


FIGURE 138. *Skrijabillanus tincae* Schigin and Schigina, 1958:

a — cephalic end, lateral; b — same, apical; c, d — caudal end of male, different aspects; e — cephalic end; f — caudal end of male, ventral; g — caudal end of female, lateral (a–d — after Shigin and Shigina, 1958; e–g — after Ergens, 1960).

Tail 0.032 mm long, with thin caudal wings which begin 0.015–0.017 mm above the genital opening and extend in wide ribbons to the end of the tail. The caudal wings are supported by three pairs of postanal pedunculate papillae situated in the anterior half of the tail. There are also 3 pairs of

sessile papillae, one pair preanal, situated slightly behind the beginning of the caudal wings, the other two pairs situated at the level of the second and third pairs of pedunculate papillae. Genital opening situated on a markedly projecting papilla. Gubernaculum and spicules absent. A chitinous rod 0.008–0.010 mm long, bent at a right angle, projects from the anterior wall of the end of the ejaculatory duct. The distal end of this rod always projects halfway outside, so that it probably has the function of the absent spicules.

Female. Length 16.5–22.0 mm, maximum width 0.047–0.065 mm. Inner width of buccal capsule 0.010 mm, outer width 0.013 mm, length 0.008 mm. Mouth 0.0067 mm wide. Caudal end bluntly rounded, with two ventrolateral processes. Vulva not found, but according to the position of the uterus, it is situated near the end of the esophagus. Viviparous. Almost the entire body cavity is occupied by the large uterus, which is filled with larvae 0.216 mm long and 0.0065 mm wide.

Excretory pore situated 0.331 mm from the cephalic end.

Description (after Ergens, 1960). Medium-sized, thin nematodes, cuticle with fine transverse striation. The cephalic end is the widest part of the body. Mouth passing into the buccal capsule, which is strongly chitinized. Esophagus consisting of a muscular and a glandular part. Viviparous.

228 Male. Length 7.0 mm, width 0.019 mm. Posterior end with well-developed caudal wings with thin papillae. Three pairs of papillae pedunculate and postanal, the following 3 pairs short and sessile, the first pair preanal and the others postanal. Genital opening situated on a tubercle in the middle of the caudal wings. Gubernaculum and spicules absent, their function apparently taken by a rectangular, curved plate.

Female. Length 15.4–19.8 mm, width 0.062 mm. Buccal capsule 0.007–0.008 mm long, 0.009 mm wide. Tail blunt, with two small processes at the end. Vulva not found; the greater part of the uterus filled with larvae.

References: Shigin and Shigina, 1958, pp. 395–399; Ergens, 1960, pp. 230–231; Molnár, 1966b, pp. 143–158; Moravec, 1968, p. 322.

Genus *Agrachanus* Tichomirova in litt.

Synonym: *Skrjabillanus* Schigin and Schigina, 1958 (in part)

Diagnosis. *Skrjabillanidae*. Body threadlike. Cephalic end rounded and slightly widened. Buccal capsule hexagonal, with strongly chitinized walls and very strong base. Six teeth at the base of the capsule. Amphids large, rounded. Esophagus entirely muscular. Females more than twice as large as males. Tail of males with 5 pairs of papillae, four pairs pedunculate and one pair sessile. Gubernaculum and spicules absent. A chitinized plate present. Vulva situated in anterior part of body. Viviparous. Parasites of fish.

Type species: *Agrachanus scardinii* (Molnar, 1966) Tichomirova in litt.

Agrachanus scardinii (Molnar, 1966) Tichomirova in litt.
(Figure 139)

Synonym: *Skrjabillanus scardinii* Molnar, 1966

Host: *Scardinius erythrophthalmus*.

Localization: serosa of posterior part of swim bladder and kidneys.

Distribution: Hungary, USSR.

Description (after Molnár, 1966b).

Male. Transparent, threadlike nematodes. Length 3.2–4.4 mm. Body cylindrical, of the same width its entire length. Cuticle smooth. Cephalic end rounded, with 4 depressed papillae and 2 amphids. Buccal capsule chitinized, 0.006–0.007 mm wide and 0.004 mm long. Esophagus not divided, cylindrical, 0.025–0.026 mm long, 0.007–0.008 mm wide. An esophageal gland extends along the esophagus. Intestine of the same width its entire length. Bursalike caudal wings present at the caudal end, one wing dorsal, the other two lateral. The lateral wings are curved ventrally, forming a sac. Caudal end strongly curved ventrally; on the dorsal side it is grooved almost
229 to the end of the dorsal wing. At the level of the last pair of papillae two riblike formations extend to the posterior end of the lobe. The part covered with these formations refracts light strongly, thus differing from the other parts of the dorsal lobe. Caudal end with 4 pairs of pedunculate and one pair of sessile papillae. The last pair of pedunculate papillae is mushroom-shaped. Sessile papillae situated between the second and third pair of pedunculate papillae. Two equal short spicules, 0.006–0.007 mm long. They project into the transversely oval subterminal cloaca.

Female. Transparent, threadlike nematodes. Length 8–13 mm, body of uniform width, 0.049–0.070 mm wide. Cuticle smooth. Four elongate papillae and 2 large amphids at the cephalic end. Buccal capsule 0.12 mm wide and 0.008 mm long, with 5 anteriorly directed teeth at its base. Esophagus of the same width throughout, opening into wide intestine through three
230 valves. Width of esophagus 0.012–0.014 mm. Intestine uniformly wide. A large esophageal gland begins below the buccal capsule; it gradually widens and extends posteriorly. At the valves of the esophagus it becomes markedly wider and extends along the intestine for double the length of the esophagus. The other esophageal gland is much narrower and extends from the middle of the esophagus to the vulva. Rectum gradually narrowing, passing into the subterminal anus. Vulva situated in anterior part of body, sometimes behind the anterior part of the uterus. Vagina short, weakly chitinized, thin, passing into the markedly widened ovejector which extends posteriorly for a short distance, then turns anteriorly to the anterior end of the uterus and makes a loop, becomes gradually wider, and passes into the uterus. The posterior end of the uterus is rounded and passes into the narrow, spirally coiled oviduct and the single ovary, the narrowed distal part of which is bent like a hook at the rectum. Tail tapering, with two dorsolateral and one ventral teatlike processes 0.003–0.004 mm long. According to the stage of development, the larvae are 0.090 to 0.140 mm long.

Description (after Tikhomirova). Thin, delicate forms. Cephalic end slightly widened. Four cephalic tubercles of the embedded type situated submedially, thin and not always distinct. Buccal capsule hexagonal.

The walls of the capsule, particularly the base, are strongly chitinized. Base of buccal capsule with 6 chitinous teeth in the form of a truncate pyramid; teeth of almost the same size except one, which is apparently reduced.

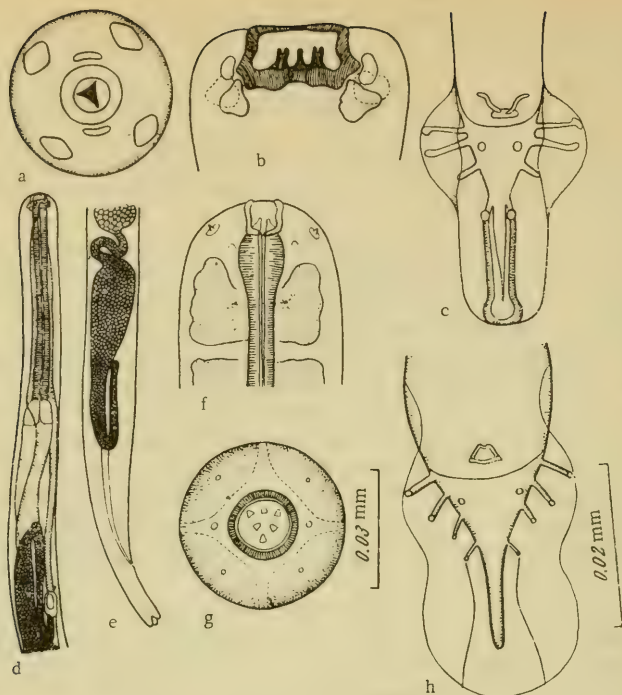


FIGURE 139. *Agrachanus scardinii* (Molnar, 1966):

a — cephalic end, apical; b — same, different aspect; c — caudal end of male, ventral; d — anterior end; e — caudal end of female, lateral; f — cephalic end; g — same, apical; h — caudal end of male, ventral (a-e — after Molnár, 1966b; f-h — after Tikhomirova).

Esophagus entirely muscular, at first widened and then of uniform width its entire length. Esophagus surrounded by distinct glands. Four cephalic papillae. Two large, rounded amphids.

Male. Length 4.5–5.0 mm, width 0.02–0.03 mm. Inner width of buccal capsule 0.010–0.012 mm, outer width 0.012–0.014 mm; length 0.005 mm. Esophagus 0.3–0.4 mm long. Caudal end with thin wings which begin slightly before the genital opening. The wings are supported by 5 pairs of papillae, four pairs pedunculate and one pair sessile, situated between the second and third pair of pedunculate papillae. Length of pedunculate papillae varying. Tail of varying form. Genital opening situated on a strongly projecting papilla. Spicules and gubernaculum absent; there is a chitinized plate 0.005 mm long, of varying thickness.

Female. Length 14.0–16.0 mm, width 0.05–0.07 mm. Inner width of buccal capsule 0.010–0.012 mm, outer width 0.018 mm; length of capsule 0.005–0.007 mm. Lateral walls of capsule 0.0018 mm thick, base 0.0036 mm thick. Mouth rounded, 0.0072 mm wide. Cephalic tubercles 0.0072×0.0108 mm large. Esophagus 0.34–0.53 mm long. Nerve ring situated 0.27 mm from the cephalic end. Vulva situated in anterior part of body; vagina short and narrow. Ovejector well developed. Uterus filled with larvae which are, according to their age, 0.07–0.13 mm long. Tail bluntly rounded, with three processes which are 0.003–0.004 mm long.

231 The life cycle was studied by Tikhomirova. She noted that the uterus of mature females is filled with larvae which are, according to their stage of development, 0.12 to 0.14 mm long. Older larvae in the uterus are very mobile. Hatching of larvae takes place periodically, growth in the uterus about 6 days. The larvae enter the muscles with the bloodstream and later the skin of the host, where they form accumulations (usually 5—6, but sometimes as many as 50 larvae are visible in a field of vision of the microscope). Larvae from the blood differ from larvae from the uterus in their large vacuoles. The larvae from the blood are more resistant, preserving their motility in water for 1—5 hours and for several hours in a drop of saline. Tikhomirova recorded carp lice of the genus *Argulus* as intermediate host, in the body cavity of which she found a larva of *Agrachanus scardinii* in a study of natural infections. In experimental infection of carp lice, she found that the larvae migrate from the intestine to the body cavity in several minutes. The larvae settle in the legs. Young specimens of *Argulus* are more susceptible to infection than adults. Usually 2—5, maximum 17 larvae were found in experimentally infected *Argulus*. During the first days in the body cavity the larvae are active and grow. On the 2nd day in the body cavity they are 0.172 mm long and after 5 days they are twice as large as larvae from the uterus. Two molts were observed in the intermediate host, 4 days and 8—9 days after infection. After they have reached the infective stage, the larvae enter the definitive host when the carp lice feed on fish. Tikhomirova used *Scardinia erythrophthalmus* as definitive host.

References: Molnár, 1966b, pp.150—157; Moravec, 1968, p.322.

Genus *Molnaria* Moravec, 1968

Synonym: *Skrjabillanus* Schigin and Schigina, 1958 (in part)

Diagnosis. *Skrjabillanidae*. Body threadlike. Cephalic end with 4 submedian tubercles directed anteriorly. Buccal capsule oval, with chitinized walls, weakly developed. Buccal cavity practically absent. Three chitinized teeth at the base of the capsule. Esophagus entirely muscular. Females more than twice as large as males. Caudal end of male with 5 pairs of papillae. Gubernaculum and spicules absent. A chitinized plate present. Vulva situated in anterior part of body. Viviparous. Parasites of fish.

Type species: *Molnaria erythrophthalmi* (Molnar, 1966) Moravec, 1968.

Molnaria erythrophthalmi (Molnar, 1966) Moravec, 1968
(Figure 140)

Synonym: *Skrjabillanus erythrophthalmi* Molnar, 1966

Host: *Scardinus erythrophthalmus*.

Localization: mesentery, serosa of intestine.

Distribution: Hungary, USSR.

Description (after Molnár, 1966b). Transparent forms, tapering at
232 both ends. Cuticle smooth. Cephalic end with 4 protruding hemispherical
papillae and 2 distinct amphids. Width of cephalic papillae 0.012 mm at the
base and 0.008 mm at the apex. Three lips surround the chitinated buccal
capsule which are 0.002 mm thick and 0.007–0.009 mm wide. Esophagus
cylindrical, 0.29–0.31 mm long. An esophageal gland extends along the esophagus
to the intestine.

Male. Length 3.3–5 mm, width 0.049–0.057 mm. Caudal end with well-developed bursalike wings consisting of longitudinal dorsal and two lateral lobes. The lateral lobes are curved ventrally, forming a sac. The dorsal part of their posterior end is markedly thinner and continues almost to the end of the dorsal lobe. Parallel to the narrow part of the caudal end extend two riblike formations dorsally to the distal end of the lobe. The part bordered by these formations refracts light differently. Two indistinct riblike formations extend laterally from the curved tail, united with the lateral lobes. Tail with 5 pairs of papillae, four pairs pedunculate. The pedunculate papillae of the first and fourth pair are mushroom-shaped. Sessile papillae are situated at the base of the third pair of pedunculate papillae. Two equal, setalike spicules 0.008–0.009 mm long. Cloaca oval, subterminal.

Female. Length 11–13.3 mm, width 0.1–0.3 mm. Mature females transparent. Caudal end with 3 oblong teatlike processes 0.008 mm long. One of the caudal processes is ventral, the other two dorsoventral. The end of the dorsoventral papillae is divided by a groove. Anus subterminal. Body cavity occupied entirely by the uterus, which is filled with larvae anteriorly and with eggs posteriorly. Larvae 0.110–0.120 mm long.

Young females 0.3–0.9 mm long. At this stage the papillae both at the cephalic and at the caudal end project more markedly. Esophagus not divided, sometimes wider than the buccal capsule, 0.30–0.36 mm long and 0.016–0.018 mm wide. Behind the buccal capsule begins a large esophageal gland which gradually widens distally, increases markedly in size above the valves of the esophagus, and continues along the intestine for twice the length of the esophagus. Another much narrower esophageal gland extends from the middle of the esophagus to the vulva. The esophagus ends in three larval valves at the connection with the widened part of the intestine which becomes narrower and ends in the anus.

Vulva situated in anterior part of body, slightly behind the anterior end of the uterus. Vagina thin, short (0.022 mm), indistinct, ovejector markedly widened. The ovejector extends at first posteriorly and then turns anteriorly and widens at the intestinal valves, turns posteriorly and passes into the uterus. Uterus of the same width its entire length, extending posteriorly and then curving and passing into the thin, spirally coiled oviduct, which then passes into the wider ovary. The narrow distal end of the ovary turns posteriorly like a hook.

Description (after Tikhomirova). Thin, transparent nematodes. Females more than twice as large as males. Body tapering at both ends. Cuticle smooth. Cephalic end with a small elliptical buccal capsule. Capsule chitinated. Inside the capsule are three chitinous teeth of almost
234 the same size. Cephalic end with 4 round cephalic tubercles situated submedially and directed anteriorly. Each tubercle bears two papillae. There are 8 cephalic papillae and two large, rounded amphids. A cuticular ring present between buccal capsule and esophagus.

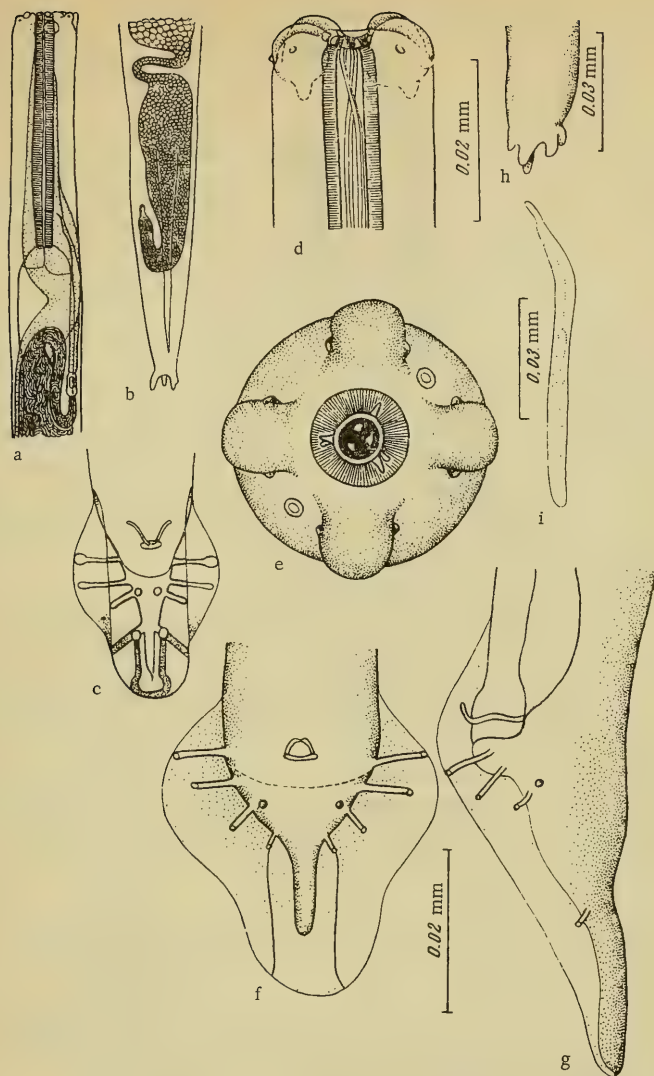


FIGURE 140. *Molnaria erythrophthalmi* (Molnar, 1966):

a — anterior end; b — caudal end of female; c — caudal end of male, ventral; d — cephalic end; e — same, apical; f — caudal end of male, ventral; g — same, lateral; h — caudal end of female; i — larva (a—c — after Molnár, 1966b; d—i — after Tikhomirova).

Male. Length 4.5–6.0 mm, width 0.05–0.08 mm. Width of buccal capsule 0.008–0.009 mm, length 0.003 mm. Cephalic tubercles 0.012–0.014 mm wide and 0.010–0.012 mm high. Esophagus muscular, 0.3–0.4 mm long, ending in three valves. Esophageal glands distinct. Caudal wings thin, beginning 0.015 mm before the genital opening. The wings are supported by 5 pairs of papillae, four pairs pedunculate and one pair sessile, situated opposite the third pair of pedunculate papillae. Three postanal pairs and

one pair of terminal pedunculate papillae are of different length: the first pair extends to the margin of the wing, the second pair only $2/3$ of its width, and the third pair a third of its width; the papillae of the terminal pair are mushroom-shaped and have short stalks. Processes of the hypodermis extend to the wings but are without papillae; they also support the wings when these are extended. The tail may be rounded, pointed, or swollen at the end. Spicules and gubernaculum absent. There is a chitinous plate, which always projects outside. Length of plate 0.006 mm. Its thickness varies. The plate is apparently a chitinization of the lower lip of the cloaca.

Female. Length 8.0–16.2 mm, width 0.2–0.4 mm. Cephalic end with 4 well-developed submedian tubercles 0.018–0.021 mm wide and 0.015–0.018 mm high. Width of buccal capsule 0.0108 mm, length 0.003 mm. Esophagus 0.35–0.5 mm long, of almost the same width throughout. Large esophageal glands present. Intestine ending 0.085 mm from end of tail. Nerve ring situated 0.266 mm from the cephalic end. Tail bluntly rounded, with three processes 0.005–0.007 mm long; two of the processes are bifid. The greater part of the genital duct extends in the long axis of the body. Vulva situated slightly below end of esophagus; vagina short and narrow, ojector well developed. Uterus filled with larvae 0.07–0.12 mm long. It passes into the oviduct and then into the ovary with thinner walls; the distal end of the ovary is curved in a hook.

Life cycle (after Tikhomirova). The uterus of mature females is filled with larvae, the length of which depends on their stage of development, 0.07 to 0.12 mm. The intermediate host is *Argulus*, in the body cavity of which the larvae parasitize. In experimental infections of *Argulus* the larvae migrated from the intestine into the body cavity in several minutes. They usually become localized in the legs. Two molts were observed in the intermediate host, 4 days and 8–9 days after entry into the host. When *Argulus* feeds on fish, larvae of the infective stage enter the definitive host: *Scardinius erythrophthalmus*.

References: Molnár, 1966b, pp.150–157; Moravec, 1968, p.322.

235 *Molnaria intestinalis* (Dogiel and Bychowsky, 1934) Moravec, 1968
(Figure 141)

Synonym: *Philometra intestinalis* Dogiel and Bychowsky, 1934

Host: *Scardinius erythrophthalmus*.

Localization: intestine.

Distribution: USSR, Hungary, Czechoslovakia.

Description (after Dogel' and Bykhovskii, 1934).

Male unknown.

Female. Length 10 mm, width 0.166 mm. Body threadlike. Cephalic end with 4 short, rounded papillae around the mouth. Esophagus straight, its anterior end widened like a funnel; buccal capsule absent. Length of esophagus 0.4 mm. Posterior end of body rounded, with a small tubercle. Anus and vulva absent. Almost the entire body cavity is occupied by the uterus, which is filled with embryos; two ovaries, at opposite ends of the body. Anterior end of uterus extending to 0.5 mm of the cephalic end, posterior end 0.2 mm before the end of the tail.

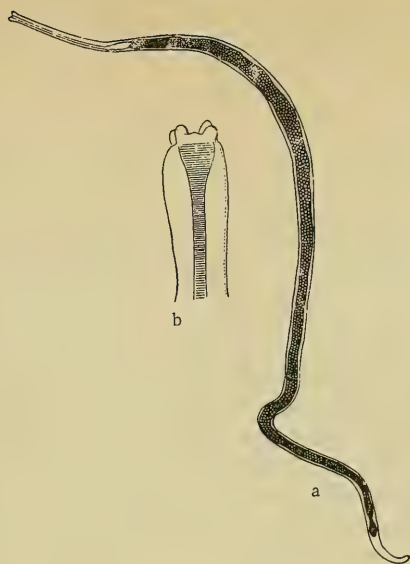


FIGURE 141. *Molnaria intestinalis* (Dogiel and Bychowsky, 1934):

a — general view; b — cephalic end (after Dogiel' and Bykhovskii, 1934).

References: Agapova, 1966, p.218; Dogel' and Bykhovskii, 1934; pp. 310—311; Molnár, 1966b, p.157; Moravec, 1968, p.322.

Molnaria leucisci (Agapova, 1963) Moravec, 1968

Synonym: *Philometra leucisci* Agapova, 1963: Ph. sp. Agapova, 1956

Host: *Leuciscus idus*.

Localization: intestine.

Distribution: USSR.

Description (after Agapova, 1963).

Male unknown.

Female. Length 5.5—6.7 mm, width of cephalic end 0.042—0.045 mm, of posterior end 0.015 mm. Females white, threadlike. Cephalic end with 4 short, rounded, distinct papillae around the mouth. Lips absent. Esophagus straight, slightly widened at the anterior end, 0.296—0.359 mm long.

236 Posterior end of body with three distinct processes 0.0076 mm long. Almost the entire body cavity is occupied by the uterus, which is filled with larvae. Vulva and anus absent. Viviparous.

References: Agapova, 1956, pp.5—60; 1963, pp.137—138; 1966, p.218; Molnár, 1966b, p.157; Moravec, 1968, p.322.

FAMILY *TETANONEMATIDAE* SKRJABIN AND
SCHIKHOBALOVA, 1948

Historical review

Steiner (1937) described *Tetanonema strongylurus* from the blood sinuses of *Bdellostoma heptatrema* and established for it the new genus *Tetanonema* Steiner, 1937, which he provisionally placed in the subfamily Aproctinae. However, Skrjabin and Shikhobalova (1948) did not agree, and because of the presence of papillae irregularly distributed on the whole body, the reduction of the esophagus, which apparently cannot receive food, the large number of papillae on the caudal end of females (Steiner considered them a character of intersexuality but he probably examined both females and males, which he considered as females because of the absence of spicules), localization in the blood of *Bdellostoma* (Cyclostomata), and other characters, they removed the genus *Tetanonema* from the subfamily Aproctinae and established the new family *Tetanonematidae* Skrjabin and Schikhobalova, 1948, which they placed in the superfamily *Dracunculoidea* Cameron, 1934, suborder *Camallanata* Chitwood, 1936 together with the *Dracunculidae* and *Cystoosidae*.

Diagnosis. Anguillicoloidea. Body threadlike, with slightly pointed anterior end; posterior end blunt. Eight cephalic papillae in the outer ring, arranged in pairs. Cuticle of anterior part of body with irregularly arranged tubercles. Intestine reduced.

Male. Caudal wings absent.

Female. Vulva situated slightly before anterior third of body.

Parasites of the circulatory system of Cyclostomata.

Type genus: *Tetanonema* Steiner, 1937.

Genus *Tetanonema* Steiner, 1937

Diagnosis. *Tetanonematidae*. Body threadlike. Cephalic end slightly pointed, posterior end blunt. Cephalic end with 4 pairs of submedian papillae in the outer ring, inner ring consisting of not always distinct lateral papillae. The region behind the cephalic end has numerous irregularly distributed tubercles. Cuticle with fine intercrossing striation. Esophagus short, reduced, consisting of barely recognizable duct and wrinkled tissue without musculature around it. Tail blunt, rounded.

Male. Caudal wings absent.

Female. Vulva situated slightly before anterior third of body. Rectum nearly obliterated.

Parasites of the circulatory system of Cyclostomata.

Type and only species: *Tetanonema strongylurus* Steiner, 1937.

237 *Tetanonema strongylurus* Steiner, 1937 (Figure 142)

Host: *Bdellostoma heptatrema*.

Localization: subcutaneous blood sinuses.

Distribution: Atlantic Ocean.

Description (after Steiner, 1937). Body threadlike; cephalic end slightly pointed, caudal end blunt. Cuticle 0.005 mm thick, with intercrossing striation. Cuticle consisting of three layers: surface layer thin, 0.0013 mm thick, staining more strongly with acid carmine than the other two layers. Eight longitudinal fields, the ventrosubmedian and dorsosubmedian fields thin and continuous, distinct only in some places; dorsal field with narrow base, consisting of a simple row of cells. Lateral fields rectangular, multicellular (12–23 cells), with wide base which widens toward the esophagus or the intestine. The lateral, dorsal, and ventral fields are more distinct in the region of the esophagus.

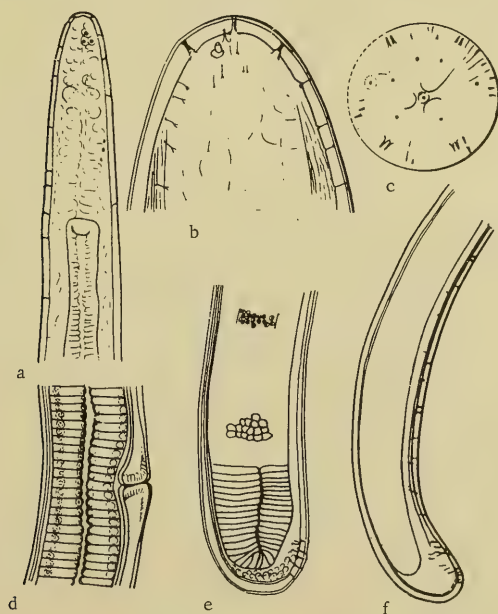


FIGURE 142. *Tetanonema strongylurus* Steiner, 1937:

a — anterior end; b — cephalic end, lateral; c — same, apical; d — région of vulva, lateral; e — caudal end of female, ventral; f — caudal end of male, lateral (after Steiner, 1937).

238 The four submedian pairs of cephalic papillae are weakly developed; they do not protrude above the surface and form the outer ring. A simple interolateral papilla often present in the inner ring. Numerous papillae are irregularly distributed behind the "head" and also at the level of the posterior part of the esophagus and in some places on the other parts of the body. Amphids small, in the form of an oval sac, their opening small, rounded, situated near the four submedian cephalic papillae.

Mouth narrow. Buccal capsule absent. Lumen of esophagus reduced, probably not absorbing food; esophageal tissue completely reduced in some places, forming compressed, irregular triangular prisms. There are numerous nuclei and also apparently three reduced esophageal glands behind the nerve ring. Intestine consisting anteriorly of 18 rectangular cells which gradually pass posteriorly into prismatic cells and increase to 29. A lumen is present only in the anterior part of the intestine, and it is widest dorso-ventrally. Intestinal contents not visible, except anteriorly, where dark coagulated masses, possibly exudative, are visible. Cells of intestine without distinct membranes, cell content light, finely granular, except for larger dark orange inclusions at the inner wall.

Male (immature). Length 166—210 mm.

Female. Length 255—275 mm. Rectum more or less obliterated. Uterus amphidelphic.

References: Skrjabin and Shikhobalova, 1948, p.100; Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.93; Campana-Rouget, 1964, pp.564—565; Steiner, 1937, pp.681—688.

SUPERFAMILY *DRACUNCULOIDEA* CAMERON, 1934

Historical review

In Volume IV of the "Key to Parasitic Nematodes" Skrjabin et al. (1954) placed three families in the superfamily Dracunculoidea: Dracunculidae, Anguillicolidae, and Tetanonematidae. The latter two families contain only one genus and species, but the family Dracunculidae has four subfamilies: Dracunculinae, Avioserpentinae, Micropleurinae, and Philometrinae. The first 3 subfamilies contain only one genus, but the subfamily Philometrinae contains 12 genera. We agree with Baylis and Daubney (1926), who considered all philometrids as a homogeneous group in the family Philometridae. Other authors (Travassos, 1960; Yamaguti, 1961b; Rasheed, 1963) placed all philometrids in this family; Yamaguti even established the new order Philometridea in 1961. However, we think that it is more correct to place all these forms in the family Philometridae of the superfamily Dracunculoidea.

We place the families Anguillicolidae, Phlyctainophoridae, Skrjabillanidae, and Tetanonematidae in the superfamily Anguillicoloidea, and the superfamily Dracunculoidea has therefore the following composition:

Superfamily Dracunculoidea Cameron, 1934

Family Dracunculidae Leiper, 1912

Subfamily Dracunculinae Stiles, 1907

Subfamily Avioserpentinae Wehr and Chitwood, 1934

Subfamily Micropleurinae Baylis and Daubney, 1922

Family Philometridae Baylis and Daubney, 1926

Subfamily Philometrinae Yamaguti, 1935

Subfamily Philoneminae n. subfam.

Diagnosis. Camallanata. Body thin. Sexual dimorphism sometimes present; males markedly smaller than females. Cephalic end rounded; stoma usually weakly developed. Anus and vulva obliterated in adult females, vulva sometimes weakly marked. Spicules present. Viviparous.

Parasites of the connective tissue, body cavity, and closed cavities and organs of mammals, fish, birds, and reptiles.

Type family: Dracunculidae Leiper, 1912.

Key to the families of the superfamily Dracunculoidea

- 1 (2). Cephalic end with a cuticular shield ... Dracunculidae Leiper, 1912.
- 2 (1). Cuticular shield at cephalic end absent Philometridae Baylis and Daubney, 1926.

FAMILY *DRACUNCULIDAE* LEIPER, 1912

Diagnosis. Dracunculoidea. Body long and thin, females markedly longer than males. Cephalic end rounded, with a cuticular shield. Lips or pseudolabia absent. Esophagus consisting of a muscular anterior part and a glandular posterior part, or entirely muscular. Anus and vulva obliterated or rudimentary in adults. Viviparous. Gubernaculum present or absent.

Type subfamily: Dracunculinae Stiles, 1907.

Key to the subfamilies of the family Dracunculidae

- 1 (2). Males with only a right caudal wing
..... Micropleurinae Baylis and Daubney, 1922 .
- 2 (1). Caudal wings absent.
- 3 (4). Circumoral ring absent on cephalic shield
..... Avioserpentinae Wehr and Chitwood, 1934 .
- 4 (3). Circumoral ring present on cephalic shield
..... Dracunculinae Stiles, 1907.

SUBFAMILY *DRACUNCULINAE* STILES, 1907

Diagnosis. Dracunculidae, with a distinct circumoral ring on the cephalic shield. Inner ring of cephalic papillae with 4–6 papillae, outer ring with 4 double papillae. Esophagus divided into a short muscular part and a long glandular part. Spicules and gubernaculum present. Vulva and anus obliterated in females. Parasites of reptiles and mammals.

Type genus: *Dracunculus* Reichard, 1759.

Genus *Dracunculus* Reichard, 1759

Synonyms: *Furia* Linnaeus, 1858; *Gordius* Linnaeus, 1758 (partim); *Vena* Gallandat, 1773; *Filaria* Müller, 1787; *Vermiculus* Dünzlison, 1858; *Fuellebornius* Leiper, 1926

Historical review

Dracunculus is the oldest genus of the suborder Camallanata.

240 Skrzabin and Shul'ts (1940) noted that the "fire snakes" mentioned in sources for at least 600 years apparently refer to the guinea worm, *D. medinensis*.

Neumann (1895) recorded the species from *Python natalensis* and named it *D. dahomensis*. Yorke and Maplestone (1926) considered it as *D. medinensis*.

Turkhud (1920) recorded it from *Naia tripudians* in India and named it *Dracunculus medinensis*.

Mackin (1927) recorded it from *Chelydra serpentina* and named it *Dracunculus globocephalus*, although he stated that except for several minor details of morphology, size, and host, *D. globocephalus* and *D. medinensis* are almost identical. Hsü (1933b) described *D. houdemeri* from *Natrix piscator* and found that the head is separated from the body by a marked constriction. This character was also noted by Mackin in *D. globocephalus*, obtained from a turtle. Hsü mentioned that during a study of Mackin's material, he found that the number and arrangement of cephalic papillae in *D. globocephalus* are the same as in *D. houdemeri*. He also found the openings of two subventral glands in *D. globocephalus* in the same position as in *D. houdemeri*. Benbrook (1932) recorded *D. medinensis* from a silver fox (Iowa, USA). He found *D. medinensis* also in a dog and mink in 1940. Hsü and Watt (1933) recorded the guinea worm in two dogs in Peiping and determined them as *D. medinensis*.

Travassos (1934) recorded *D. fuelleborni* in an opossum in South America. Mirza and Basir (1937) described *D. medinensis* from Varanus and noted that *Dracunculus* from man occurs also in animals.

Brackett (1938) recorded the guinea worm from *Thamnophis sirtalis* and named it *D. ophidensis*. He found variation of the species, e.g. in the number and arrangement of the genital papillae in males and in the length of the spicules. Goble (1942) recorded *D. medinensis*, a specimen in each hind leg of *Mustela cicognanii* from a swamp near Diana (Lewis County, New York State). Chandler (1942) found it in six out of nine raccoons examined and identified it as *D. insignis* Leidy, 1858. He noted that the arrangement of the papillae resembles that in the description and drawing of Travassos but that the embryos are identical with those of *D. medinensis*. Chabaud (1960b) found a male in *Acrantophis madagascariensis* and described it as *Dracunculus doi*. Deshmukh (1969) described the new species *Dracunculus alii* and *D. coluberensis*. The first species was described from several males in the body cavity and mesentery of *Natrix piscator* (*D. houdemeri* Hsü, 1933 had already been described from the same host, but Deshmukh did not compare his new species with it); the description of the second species was based on a single male from the lungs of *Coluber helena*; it is probably a species of Filariata, not Camallanata, and we therefore do not describe this species here.

Thus, 10 species of this genus have been described so far, three from mammals and six from reptiles.

241 The systematic position of the genus was determined only recently, although the life cycle of *D. medinensis* was described by Fedchenko back in 1872 and much has been published on the genus *Dracunculus* since. Some authors place the genus even now in the Filariata.

A serious obstacle to the study of the species of this genus is the difficulty in finding males. There are even remarks which doubt the existence of males. The reason is the biology of the parasites; the long females are

found easily under the skin, but the males have been overlooked. Moorthy (1937) and Onabamiro (1956) mentioned other factors like the early copulation of the species, the slow movement of the males after copulation, their localization in the tissues in which copulation takes place and their shorter life span.

An important description of the male of *D. medinensis* was given in 1937 by Moorthy. Brackett (1938) gave a new generic diagnosis of *Dracunculus* according to Moorthy's data and his own from a study of *D. ophidensis*. Brackett, 1938, the life cycle of which he described. Comparing the species of the genus *Dracunculus*, Brackett and Moorthy placed great importance on the caudal armature of the male, considering it as the most important character for differentiation. Desportes (1938) and Chabaud and Campana (1949) were doubtful about this criterion. Chabaud and Campana stated that the differences are not decisive for all dracunculids. Desportes showed the importance of individual variations of the tail of males, and realized that it is impossible to base the diagnosis only on these characters, as Moorthy and Brackett had done. These authors refused to give a classification and diagnosis based on a few characters alone, but that the caudal armature of the male is important emerges from the key to the species of the genus *Dracunculus* given by Chabaud and Campana. The form of the spicules, gubernaculum and genital papillae have an important place in this key. Chitwood (1933a) identified a form found in North American carnivores as *D. medinensis*, but in 1950, after description of the male, he identified it as *D. insignis* (Leidy, 1858), noting, however, that this description differs only slightly from the description of Moorthy (1937a) and that when further material has been examined, the characters of the two species may overlap. Chitwood stated that the identification of *D. fuelleborni* is doubtful. Chandler (1942) stated that it was probably identical with *D. insignis*.

242 Mirza and Roberts (1957), on the basis of material from the subcutaneous tissue of *Natrix sipedon*, described structures which had been found in other species of *Dracunculus* but not mentioned by some authors or had been shown in drawings but not mentioned in the text; they came to the conclusion that the number and arrangement of the genital papillae were the same in their specimens as in *D. medinensis*, *D. houdemeri*, *D. globocephalus*, and *D. ophidensis*. They also noted that the mouth of males is surrounded by a cuticular crest, from which extend 4 posterior spinelike processes, and that these, according to published data (Hsü, 1933b; Travassos, 1934; Brackett, 1938; Moorthy, 1938a), are present in the males of *Dracunculus* but may or may not be present in females. As there are many variations in the same species, the authors concluded that their specimens from *Natrix sipedon* belong to the species described by Mackin (1927) and Brackett (1938).

One male in the material from *Natrix sipedon* had spicules of almost the same length; two others had spicules of different length. The spicules cannot therefore be used to distinguish species of *Dracunculus*.

Mirza and Roberts doubt the validity of *D. houdemeri*, since Hsü (1933a) distinguished his species from the other species because the head is smaller than the body and separated from it by a constriction. However, this cannot be used as a specific character, since it was based on a single female, which may have been damaged or deformed because of age or bad fixation.

Mirza (1957) studied a large material from almost all animals recorded as definitive hosts of the species of *Dracunculus*. In a study of numerous females of *D. medinensis* he found that the number and arrangement of the cephalic papillae vary according to the age of the nematode.

Mirza concluded that there are only two species, one species which parasitizes mammals and another which parasitizes reptiles.

Chitwood (1933b) had stated that wild mammals in North America are infected by *Dracunculus medinensis*, which is widely known from man in the Old World. He wrote that the guinea worm occurs only in animals probably because of sanitation conditions in the United States. This could be a physiological variety which has not become adapted to man, or the life conditions are the reason that so far no natural infections of man by this parasite have been found in America.

In other countries, where conditions are different, this is probably a common parasite of man and only occasionally found in animals. *D. medinensis* has been recorded in dogs and wild animals in the USSR, where the parasite has not been found in man since the guinea worm was eradicated in Middle Asia by improved sanitation. The following authors have recorded this species from animals: Isaev (1934b) from dogs, Petrov and Chertkova (1946, quoted in Murtazaev, 1965) from badgers, Chernyshev (1954) from jackals, badgers, and jungle cats, Dubnitskii (1959) from red fox, Petrov and Chubabriya (1955) from the domestic cat, and Moskvina (1958), Ch'ung-Hsiung (1958), and Murtazaev (1965) from dogs. Boev (1964) wrote: "There is no doubt that in Middle Asia and in the south of Kazakhstan there are natural foci of *Dracunculus* infections where the parasite apparently circulates between carnivores and *Cyclops*."

If it is remembered that in all experiments studying the life cycle of *D. medinensis* dogs and cats are used, although the intensity of infection is lower, and that most cases of natural infection of dogs have been recorded in areas where the human population is not affected: China, Cairo, Uganda, Argentina, and North America (R. Müller, 1968), Mirza's view (1957) that there is only one species of *Dracunculus* parasitizing mammals and man is apparently correct.

Yamaguti (1961b) established the new genus *Chelonidracunculus* for *Dracunculus globocephalus* and the genus *Ophiophracunculus* for *Dracunculus dahomensis*, *D. ophidensis*, and hypothetically for *D. houdemeri*. He considered the differences between these genera as so marked that he even placed his new genera in different subfamilies, although he probably knew the studies of Mirza and Mirza and Roberts and was aware of the minor differences between the species of *Dracunculus* as given by these authors in their descriptions.

According to the above, the genus *Dracunculus* contains at present only two species: *D. medinensis* (Linnaeus, 1758), a parasite of mammals, and *D. oesophagea* (Polonio, 1859), a parasite of reptiles. *Dracunculus insignis* (Leidy, 1858) and *D. fuelleborni* Travassos, 1934 are synonyms of *Dracunculus medinensis*, and *D. dahomensis* (Neumann, 1895), *D. ophidensis* Brackett, 1938, *D. globocephalus* Mackin, 1927, *D. houdemeri* Hsü, 1933, *D. doi* Chabaud, 1960, and *D. alii* Deshmukh, 1969 are synonyms of *Dracunculus oesophagea* (Polonio, 1859).

Diagnosis. Dracunculinae. Anterior end with a circumoral elevation which usually projects strongly and is of variable form. Circumoral ring present. Mouth small. Inner ring of cephalic papillae consisting of 4—6 papillae (the interolateral papillae always separated, the interodorsal papillae sometimes partly fused). Outer ring consisting of 4 double papillae. Amphids present behind the lateral papillae of the outer ring. Cervical papillae situated slightly behind the nerve ring. Esophagus consisting of a muscular anterior part and a glandular posterior part. The muscular anterior part is very short. The glandular part is long and divided by a constriction into two parts, a short anterior part and a longer posterior part. Nerve ring surrounding esophagus in the region of its constriction. Intestine straight. Phasmids distinct. Female much larger than male.

Male with 10—13 pairs of genital papillae, some of them preanal and some postanal, their arrangement varying. Spicules usually of the same or nearly the same length. Gubernaculum present. Genitalia forming a straight duct; testis and ejaculatory duct indistinctly connected. Tail forming a tight spiral.

Vulva situated in anterior part of body, near the cephalic end; vulva atrophied or closed in adult females. Vagina extending anteriorly for a short distance. Two branches of uterus, united in a thin-walled duct before and behind the vulva. In mature females the uterus occupies the entire body cavity. Ovaries straight or curved at the end. Viviparous.

- 244 Larvae which have emerged in the uterus have a long, thin tail, but their tail is short and bilobed in the infective stage. Adult specimens parasitize in the connective tissue of mammals and reptiles, larvae in Copepoda.

Type species: *Dracunculus medinensis* (Linnaeus, 1758).

***Dracunculus medinensis* (Linnaeus, 1758)**

(Figures 143, 144)

Synonyms: *Gordius medinensis* L., 1758; *Vena medinensis* Gallandat, 1773; *Dracunculus graecorum* Gruner, 1777; *Filaria medinensis* Gmelin, 1790; *Furia vena medinensis* Modeer, 1795; *Filaria tropica* Rudolphi, 1809; *F. aethiopica* Valenciennes, 1856; *F. insignis* Leidy, 1858; *Dracunculus aethiopicus* Diesing, 1861; *Filaria guinensis* Dunglison, 1893; *Vermiculus capillaris* Dunglison, 1895; *Fuellebornius medinensis* Faust, 1929; *Dracunculus insignis* (Leidy, 1858); *D. fuelleborni* Travassos, 1934

Hosts: definitive — man, *Canis familiaris*, *Procyon lotor*, *Putorius vison*, *Vulpes fulva*, *Mustela erminea*, *Lutra canadensis*, *Ondatra zibeticus*, *Didelphis aurita*; intermediate — *Cyclops coronatus*, *C. quadricornis*, *C. oithonoides*, *C. vicinus*, *C. hyalinus*, *C. uljanini*, *C. strenuus*, *Macrocyclus fuscus*, *Mesocyclops leuckarti*, *Eucyclops serratus*, *Acanthocyclops bicuspidatus*, *Tropocyclops prasinus*, *Orthonoides* sp.

Localization: connective tissue and subcutaneous fat in definitive hosts; body cavity in intermediate hosts.

Distribution: Africa, tropical and subtropical Asia, South, Central, and North America.

Description (after Moorthy, 1937a).

Male. Length 12–29 mm, width 0.4 mm. Mouth small, surrounded by two rings of papillae. Inner ring consisting of 4–6 distinct papillae, the interolateral papillae always distinctly separated, the interodorsal and interoventral papillae sometimes partly fused. Outer ring always consisting of 4 double papillae. Amphids situated behind the interolateral papillae. Cervical papillae situated slightly behind the nerve ring. Length of esophagus 9.6 mm in a specimen 26 mm long. The esophagus consists of a short muscular anterior part and a long glandular posterior part which is constricted near the nerve ring. Anus situated 0.25 mm from end of tail. Ten pairs of caudal papillae, four pairs preanal and six pairs postanal. Counting from the caudal end, the first pair of papillae is ventrolateral, the second and third pairs subventral, not separated, the fourth pair ventral, situated near the third, and the fifth and sixth pairs some distance before the fourth, the fifth pair ventrolateral and the sixth subventral. The four pairs of preanal papillae form two rows which begin ventrolaterally and are directed subventrally. The first pair is adanal or situated slightly before the anus; the other three pairs are preanal. Phasmids lateral, situated behind the fifth pair of papillae. Spicules of almost the same length, 0.49–0.73 mm; gubernaculum 0.2 mm long.

Female. Length 1.5–53.0 cm, width 1 mm. Rectangular circumoral elevation present. Mouth surrounded by two rings of papillae. Inner ring consisting of 4 papillae; interolateral papillae separated, interodorsal and interoventral papillae partly fused. Outer ring consisting of 4 double papillae. Amphids situated behind the interolateral papillae. Length of esophagus 10 mm in a specimen 24 mm long. Intestine pigmented in young individuals; the pigmentation gradually disappears in old specimens. Anus situated 0.25 mm from end of tail in a female 24 mm long and 0.9 mm from this end in a female 50 cm long. The end of the tail of young females has four caudal spines. Vulva situated 10.3 mm from the cephalic end in a female 24 mm long.

Description (after Travassos, 1934, as *D. fuelleborni*).

Male. Length 27–29 mm, width 0.29–0.30 mm. Caudal end spirally coiled. Cephalic end with a chitinized shield with two not protruding lips which barely accommodate a distinct pair of papillae. Cephalic shield 0.100–0.117 mm wide. Buccal capsule reduced, esophagus rudimentary. Under the cephalic shield is a chitinized strengthening in the form of a funnel between the buccal cavity and the cuticle. Esophagus 0.57–0.61 mm long, weakly developed, represented in the posterior part by a nontransparent cell membrane which apparently has a glandular function; membrane 0.28×0.18 mm large.

Tail with markedly reduced lateral wings, conical, with distinct, slightly asymmetrical papillae. Papillae arranged on the ventral side as follows: 3–4 pairs preanal, one pair adanal, 4–6 pairs postanal, more or less equally spaced. Cloaca situated 0.38–0.42 mm from end of tail. Spicules of almost the same length, 0.38–0.42 mm long. Gubernaculum weakly chitinized, with indistinct outline, 0.88–0.100 mm long, 0.032 mm wide. Genital duct almost straight, its anterior end folded double, its anterior part situated 0.85 mm from the cephalic end.

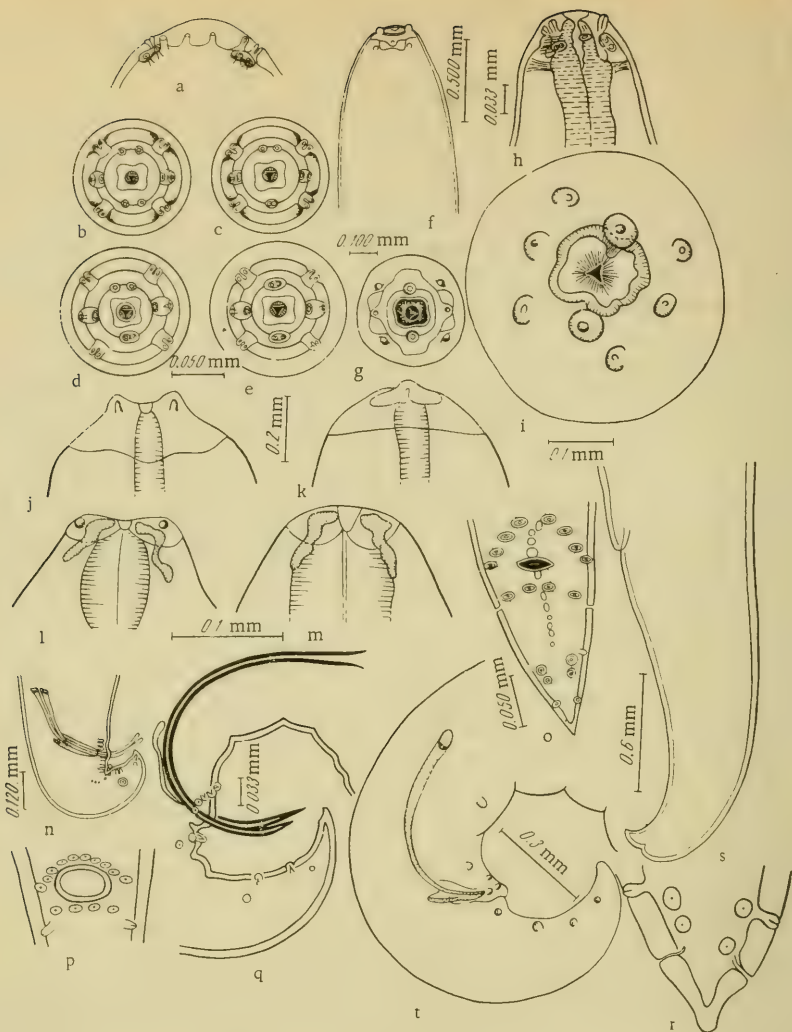


FIGURE 143. *Dracunculus medinensis* (Linnaeus, 1758).

Cephalic ends: a-e — after Moorthy, 1937; f, g — after Skrjabin and Shul'ts, 1931; h — after Chitwood and Chitwood, 1950; i-m — after Travassos, 1934. Caudal ends: n, o — after Moorthy, 1937; q, r — after Chitwood and Chitwood, 1950; s, t — after Travassos, 1934; p — region of cloaca — after Chitwood and Chitwood, 1950.

Female. Length 465–490 mm, width 1.5 mm. Body cylindrical, cuticle with fine transverse striation. Cephalic end with two small protruding lips and strengthened by a chitinized shield which is slightly yellowish and about 0.400 mm wide. Lips situated in the midline, dorsally and ventrally. The rounded mouth has 3 pairs of papillae: a pair of lateral, a pair of subventral, and a pair of subdorsal papillae. Buccal cavity very small, with a chitinized strengthening between it and the cuticle. Esophagus rudimentary, about 1 mm

long, without distinct transition to the intestine. Lateral fields light and transparent, median fields not transparent. Musculature polymyarian, consisting of cells of a pear-shaped protoplasmic body protruding into the cavity.

Tail curved ventrally; anus situated 1.2 mm from end of tail. Rectum rudimentary. Genitalia amphidelphic, with diverging straight uteri. Ovaries folded double above the uteri, relatively short and thin. The posterior uterus extends beyond the anus; the anterior uterus ends 20 mm from the cephalic end. The position of the vulva was not determined, but it is probably situated in the middle of the body. The larvae have a primordium of the intestine and a distinct anus. A pair of teatlike processes situated laterally slightly before the anus. Length of larvae 0.300–0.429 mm, width 0.06 mm. Anus situated 0.096 mm from end of tail, papillae 0.100 mm from this end.

Description (after Chitwood, 1950, as *D. insignis*).

247 Male. Length 17–22 mm, width 0.240 mm. Length of esophagus 13–14 mm, of muscular anterior part 0.3 mm. Nerve ring situated 0.62 mm, cervical papillae 0.70 mm, excretory pore 0.80 mm from the cephalic end. Tail 0.35 mm long. Spicules of the same length, 0.46–0.495 mm long; gubernaculum 0.119 mm long. Five pairs of obliquely arranged preanal papillae. The postanal papillae are arranged in a transverse row, two pairs subventral and one pair ventrolateral, then follow two pairs of subventral papillae and behind them paired lateral phasmids.

The first study of the life cycle of *D. medinensis* was published by A. P. Fedchenko (1870–1872), who determined that *Cyclops* is the intermediate host.

Fedchenko studied the larvae in the body cavity of the intermediate host, and described the mode of entry of the larvae of *D. medinensis* into *Cyclops*. He thought that the larvae attach themselves to the legs of the crustacean and then penetrate into the body through the abdominal integument. That the larvae actively penetrate into *Cyclops* was also stated by Blanchard (1890), Manson (1893), and Wenyon (1908). Ikov (1886) stated that the larvae enter *Cyclops* passively, and this was accepted by Leiper (1907), Roubaud (1913), and Chatton (1918).

Massino (1926) observed larvae penetrating into the body cavity of *Cyclops* through a damaged intersegmental slit. This author acknowledged the passive entry of the larvae, but did not deny possible active penetration.

The most thorough study of this problem was made by Isaev (1934 a–c), who contributed much to the eradication of dracunculiasis in the USSR. Isaev (1924–1931) came to the conclusion that the penetration of larvae of *D. medinensis* into the intermediate host takes place passively, when they are swallowed by *Cyclops*. Golvan and Lancaster (1968) think that *Cyclops* deliberately swallow the larvae.

Data on the metamorphosis of larvae of *D. medinensis* in the intermediate host are very contradictory.

Fedchenko (1871) observed larvae in infected *Cyclops* and established that they became infective after 12 days. Manson (1893) stated that molting of larvae of *D. medinensis* is delayed for six weeks. Leiper (1907) observed that embryos shed the cuticle after 8 days. After 2 days the larvae lose the delicate transparent membrane, and growth and differentiation of the internal organs take place in the fifth week, when they apparently become mature (after Moorthy, 1938). According to Fairley and Linston (1924), the

larvae of *D. medinensis* become infective about 15 days after infection of *Cyclops*.

Isaev (1934a) established that the larvae become infective 13 days after infection of the intermediate host and that two molts take place in the body cavity of *Cyclops*.

Manson-Bahr (1935) observed that the larvae shed the cuticle two or three times.

Craig and Faust (1937) stated that the metamorphosis of the larvae in the body cavity of *Cyclops* involves one, possibly two molts and that the larvae sometimes become infective after 10–12 days.

(248)

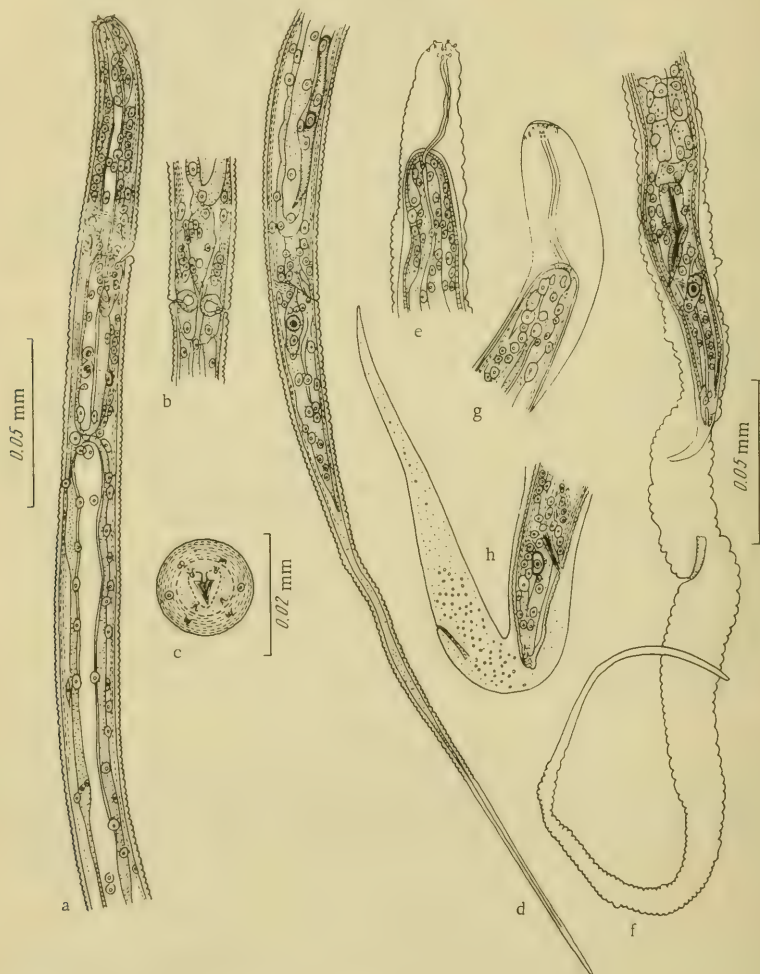


FIGURE 144. *Dracunculus medinensis* (Linnaeus, 1758).

Larvae at different stages of development:

a — anterior half of first-stage larva, lateral; b — region of phasmids of first-stage larva, ventral; c — cephalic end of first-stage larva, apical; d — posterior half of first-stage larva, lateral; e — cephalic end of larva during first molt in *Cyclops*; f — caudal end of larva during first molt in *Cyclops*; g — cephalic end of larva during second molt in *Cyclops*; h — caudal end of larva during second molt in *Cyclops* (after Moorthy, 1938a).

Moorthy and Sweet (1936a, b) gave a brief description of two types of second-stage larvae of *D. medinensis*, assuming that they are probably different sexes. However, Moorthy (1937a) disclaimed this view. In the same paper he gave a description of the later stages of development of the larvae in *Cyclops*, noting that two molts take place: after 5–7 days and after 8–12 days at 32–33° and after 8–12 days and after 13–16 days at 12–20°.

According to Golvan and Lancastre (1968), the first molt in *Cyclops* takes place after 8 days and the second after 22 days.

Infection with larvae of *Dracunculus* causes retardation of the development of the intermediate host: infected immature *Cyclops* do not become mature, and infected adult females do not form egg sacs. With a low intensity of infection (to 4 specimens) all the larvae complete their development in *Cyclops* at the same time, in a higher intensity of infection, the first or second molt was observed only in a few larvae. Complete development of the larvae in the host is protracted for 7–10 days under these conditions.

Moorthy (1938a) stated that if *Cyclops* infected with 2–3 larvae are superinfected with a new quantity of larvae 2–3 weeks later, i. e., after the first larvae have completed their development, 60–70% of the *Cyclops* die in 24 hours. If there are more than 5 larvae in the second infection, they show the same delay in development as in a normal infection.

Isaev (1934b) infected dogs experimentally with *D. medinensis* by feeding them *Cyclops* infected with larvae of *Dracunculus* and found that the development of *D. medinensis* in the dogs lasted 9–10 months. He noted that the infection of *Cyclops* and of the dogs was equally successful when it was carried out with larvae from man and with larvae from experimentally infected dogs.

Experiments to infect dogs with *Dracunculus* were also made by Moorthy and Sweet (1936a, b; 1938) and Onabamiro (1956). They used dogs one month or 1–5 months old. Moorthy and Sweet (1938) stated that all the dogs which were successfully infected had earlier been heavily infected with *Acanthocephala*. They therefore assumed that such dogs became infected more easily than healthy dogs, since ulceration of the intestine facilitated the penetration of the larvae, or the resistance of the animals was perhaps lowered. Onabamiro (1956) used therefore only month-old dogs in his experiments, since they are usually still not infected with helminths. He used infective larvae taken from *Cyclops*, or infected *Cyclops*. The experiments of Moorthy and Sweet (1938) to introduce larvae of *D. medinensis* under the skin of dogs and intravenously were negative.

There is no definite knowledge of the development of *D. medinensis* in the definitive host. It is assumed that after they are released in the intestine after the *Cyclops* are digested, the larvae penetrate through the walls of the stomach and intestine and develop further in the mesentery, reaching their final location through the lymphatic system. Supryaga 250 (1967a) found for *Avioserpens mosgovoyi* and Adams (1969) for *Philonema oncorhynchi* that the parasites move actively through the tissues to their definitive location. Since these species are closely related to *D. medinensis*, it may be assumed that the migration of *D. medinensis* in the definitive host is similar. Onabamiro (1956) studied the development of *D. medinensis* in the definitive host, but could not follow

the development of the worms to 40 days after infection; 43 to 48 days after infection the nematodes were found mainly in the region of the axillary and inguinal lymph glands, so that Onabamiro concluded that the larvae migrate first along the lymphatic channels.

Müller (1968) assumed that the third molt probably takes place 15 to 22 days after infection.

Onabamiro (1956) thought that the third molt takes place during the migration of the larvae into the deeper tissues. He observed the fourth molt of *D. medinensis* when he dissected a dog 43 days after infection. Males of *D. medinensis* were not found in experimentally infected animals 6 months after infection. According to Supryaga (1967a), males of *A. mosgovoyi* may live for two years in the definitive host.

Dracunculiasis is an ancient and endemic parasitic disease in tropical and subtropical countries in the Orient. In the opinion of Isaev, it first appeared in Africa as a disease of natural foci of wild animals living near small water bodies. Primary foci of dracunculiasis of man are known from Africa, Arabia, and India. Negro slaves apparently introduced the disease to America, where it became endemic in South America. Isolated cases have been recorded in persons not of local origin in Europe.

In the Soviet Union endemic foci of dracunculiasis existed in Uzbekistan, where the entire population of towns and villages was sometimes infected. The people of Bukhara, Dzhizak, Karshi, and Samarkand suffered particularly from the disease; the most ancient and persistent focus was in Bukhara. Under the supervision of Isaev, dracunculiasis was eradicated in the USSR in 1931.

Dracunculiasis is found in persons of all ages but usually in people 20 to 40 years old. Lesions may be single or multiple; one to 50 or more parasites may be found in a patient. The parts of the body affected are those which come most frequently in contact with water, and therefore 86% of all infections are in the legs.

Females complete their development in the definitive host in 9–14 months without any outward symptoms of disease. Dracunculiasis is manifested clinically only a few hours before local changes of the skin are found, beginning with short-term, sometimes severe prodromal symptoms accompanied by itching, erythema, and urticaria. Vertigo, syncopes, irritability, even delirium and dyspnea are sometimes present. These prodromal symptoms continue 2–3 days. Then local symptoms appear in the form of a characteristic inflammatory infiltration. The skin above the cephalic end of the parasite turns red, the inflammatory focus becomes raised, to the size of a walnut, on the apex of which a blister is formed. After sometime the blister bursts and discharges a milky-white fluid containing a large number
251 of larvae. The cephalic end of the parasite projects through the opening and the symptoms of the prodromal period of the disease disappear. The necrotic whitish mass surrounding the cephalic end of the parasite and visible when the blister bursts usually becomes detached of its own accord after 11 days but it may be removed earlier by operation.

The dangers of dracunculiasis are its complications: a parasite which penetrates into the joints may cause ankylosis. The disease may develop complications after secondary infections, and abscesses, phlegmonae, gangrene, and also arthritis, synovitis, and epididymo-orchitis may occur.

The diagnosis of the disease is easy, since the parasite is localized in the subcutaneous tissue and is often visible under the skin.

Treatment. The prodromal symptoms disappear completely after administration of adrenalin. The popular treatment of dracunculiasis, the most ancient and the most effective, is removal of the parasite. The protruding cephalic end is carefully drawn out and wound around a piece of gauze so that it cannot be retracted, and the wound is bandaged. This is repeated for several days until the whole worm has been removed; it is not recommended to extract the parasite rapidly, since it may break, and treatment is then more complicated and recovery delayed.

In Dzhizak and Samarkand the usual practice is to remove the worm in one operation by opening the skin blister.

Epidemiology and prophylaxis. The source of human infection with dracunculiasis are water bodies containing infected *Cyclops*. In Old Bukhara such water sources were cisterns which were filled with water from irrigation canals. The water from the cisterns was brought to houses by water carriers.

Water bodies became infected when ceremonial ablutions were made and water carriers were therefore often infected with *D. medinensis*.

Control of the parasite directed by Prof. Isaev consisted in breaking the contact between the parasite and man, by eradicating *Cyclops* in water bodies, and in treating patients and improving the water supply.

Isaev suggested the following measures for the control of dracunculiasis:

1. Detection of infected persons, a census, and rendering the parasites harmless.

2. Elimination of infected *Cyclops* in cisterns; cleaning of all urban cisterns; draining of all water bodies and refilling them with fresh water.

3. A campaign to acquaint the population with measures of control of dracunculiasis through social and individual prophylaxis (a precautionary measure is to drink only boiled water and to wash fruit and vegetables).

References: Boev, 1964, pp. 4-6; Dubnitskii, 1950, pp. 323-328; Fedchenko, 1870, p. 71; 1872, pp. 1-24; 1873, pp. 51-68; Ikov, 1886, p. 1; Isaev, 1926, pp. 12-16; 1930, pp. 51-53; 1934a, p. 212; 1934b, p. 231; 1934c, p. 238; Litvinov, 1968, pp. 347-350; Massino, 1926, pp. 639-644; Moskvina, 1958, pp. 124-125; Murtazaev, 1965, pp. 99-101; Petrov and Chubabriya, 1955, pp. 231-233; Pod'yapol'skaya and Kapustin, 1958, p. 366; Skrzjabin and Shikhobalova, 1948, p. 607; Skrzjabin and Shul'ts, 1931, p. 768; 1940, p. 470; Skrzjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 64; Bastian, 1863, pp. 101-134; Baylis, 1939, pp. 63-66; Benbrook, 1932, pp. 821-824; 1940, pp. 260-262; Blanchard, 1890, pp. 9-10; Brackett, 1938, pp. 353-361; Chabaud, 1960a, pp. 100-103; Chabaud and Campana, 1949, pp. 67-76; Chandler, 1941, pp. 153-157; pp. 255-268; Chatton, 1918, pp. 338-348; Cheatem and Cook, 1948, pp. 421-423; Chitwood, 1933a, pp. 802-804; 1950, pp. 14-15; Cinotti, 1906, pp. 466-470; Craig and Faust, 1937, pp. 329-332; Deshmukh, 1969, pp. 105-110; Desportes, 1938, pp. 305-326; Dickmans, 1948, pp. 39-40; Donges, 1966, pp. 252-256; Erickson, 1946, pp. 494-509; Ewing and Hibbs, 1966, pp. 515-519; Fairley and Linton, 1924, pp. 93-103; Farmer and Witter, 1952, p. 174; Goble, 1941, p. 221; Golvan and Lancastre, 1968, pp. 705-710; Helmoldt and Jungherr, 1955, pp. 463-469; Hinz, 1965, pp. 90-103; Hsü, 1933, pp. 101-118; Hsü and Hoepply, 1931, pp. 567-588; Hsü and Watt, 1933, p. 1326; Hughhins,

1958, pp. 40–46; Kothari, Pardnani, Menta and Anand, 1968, pp. 435–436; Layne, Birkenholz and Griffo, 1960, p. 685; Leiper, 1907, pp. 129–132; 1910b, pp. 65–66; 1913, p. 265; Leuckart, 1876, pp. 109–112; Mackin, 1927, pp. 91–94; Manson, 1893, pp. 947–961; Manson-Bahr, 1935, pp. 893–961; Mirza, 1929, pp. 129–156; 1957, pp. 44–47; Mirza and Basir, 1937, pp. 26–32; Mirza and Roberts, 1957, pp. 40–43; Moorthy, 1937, pp. 220–224; 1938, pp. 437–460; Moorthy and Sweet, 1936, pp. 437–442; 1936, p. 568; 1938, p. 301; Moravec, 1963, pp. 378–379; 1966, pp. 281–283; Müller, 1966, pp. 431–432; 1967, pp. 747–750; 1968, pp. 331–338; Neumann, 1895, pp. 123–127; Onabamiro, 1950, p. 31; 1954, p. 180; 1956, pp. 157–166; Raffier, 1965, p. 350; Reddy and Valli, 1967, pp. 23–25; Roubaud, 1913, pp. 281–288; Schwabe, 1956, p. 651; Siegler, 1946, p. 179; Strassen, 1907, pp. 110–129; Travassos, 1934, pp. 235–238; Turk, 1950, pp. 215–216; Turkhud, 1920, p. 727; Valenciennes, 1856, p. 259; Wenyon, 1908, pp. 432–135; Wilson, 1958, p. 256; Yamaguti, 1961, pp. 677–678; Yorke and Maplestone, 1926, p. 442.

***Dracunculus oesophagea* (Polonio, 1859)**
(Figures 145–147)

Synonyms: *Filaria oesophagea* Polonio, 1859; *F. dahomensis* (Neumann 1895); *Dracunculus dahomensis* (Neumann, 1895); *D. globocephalus* Mackin, 1927; *D. houdemeri* Hsü, 1933; *D. oesophagea* (Polonio, 1859); *D. ophidensis* Brackett, 1938; *D. doi* Chabaud, 1960; *D. alii* Deshmukh, 1969

Hosts: definitive – *Thamnophis sirtalis*, *Natrix sipedon*, *N. piscator*, *Tropidonotus natrix persa*, *T. natrix natrix*, *T. viperinus*, *Python natalensis*, *Psammophis sibilans*, *Acrantopsis madagascariensis*, *Chelydra serpentina*; intermediate – *Cyclops viridis*; reservoirs – sticklebacks.

Localization: connective tissue in definitive hosts, body cavity in intermediate hosts and reservoirs.

Distribution: North America, Indochina, Africa, Madagascar, Italy.

Description (after Neumann, 1895, as *D. dahomensis*).

Male. Length 4.8 cm, width 0.34 mm. Body gray, tapering only posteriorly. Tail forming a spiral of four coils. Cuticle 0.003–0.004 mm thick, with marked longitudinal striation; transverse striation fine and dense, with intervals of 0.0015 mm. Lateral lines wide, each of them occupying about 1/5 of the circumference of the body, Cephalic end with 8 papillae. Tail conical, with recurved end.

Spicules of almost the same length, 0.400–0.425 mm. One pair of preanal papillae, two pairs of postanal papillae, the last pair near the end of the tail.

Female. Length 50–80 cm, width 1–1.25 mm. Cuticle 0.006–0.010 mm thick, transparent, homogeneous, with transverse striation with intervals of 0.0025–0.006 mm. Lateral lines very wide, occupying a quarter of the circumference of the body, consisting of a granular substance in which are scattered rounded or oval cells, 0.018–0.022 mm wide. Median lines difficult to see, even in microscopic sections. Muscles arranged as in *D. medinensis*.

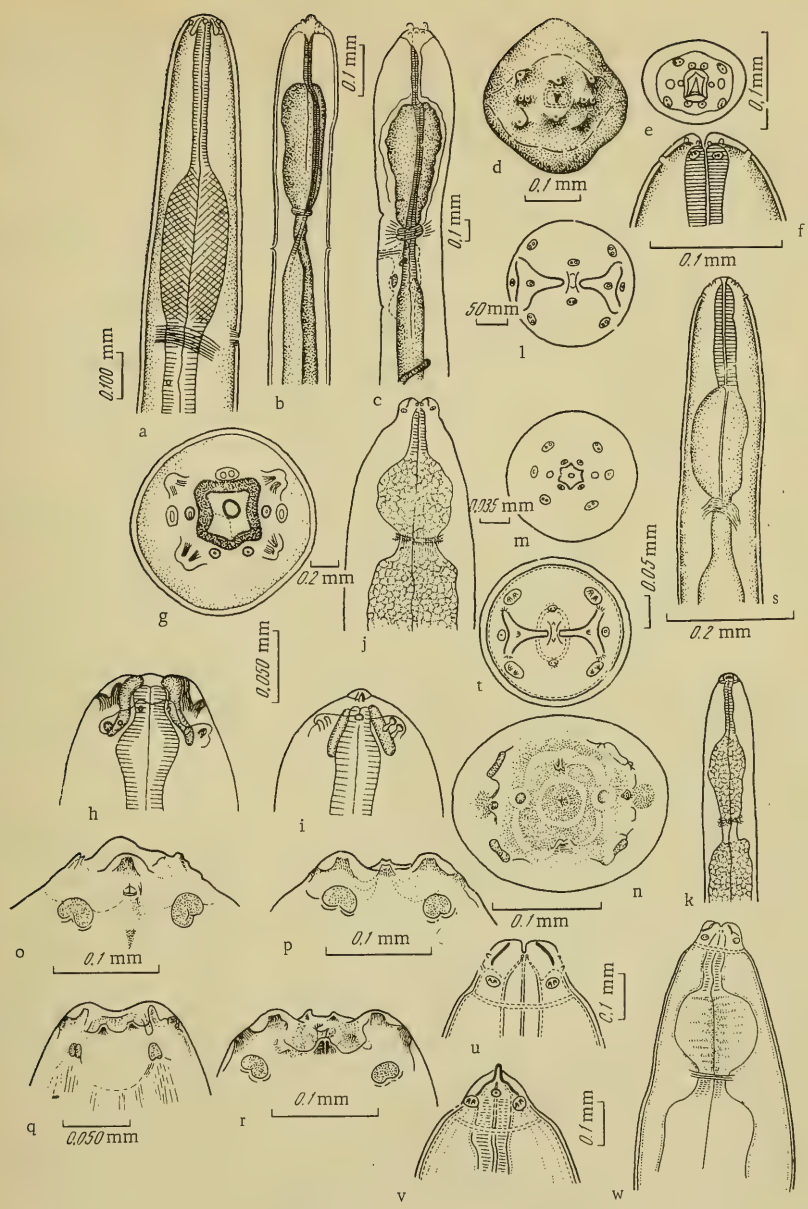


FIGURE 145. *Dracunculus oesophagea* (Polonio, 1859).
Cephalic end, different aspects: b-d — after Mackin, 1927; a, g-i — after Chabaud, 1960;
j, l, t-w — after Hsü, 1933b; k, m — after Brackett, 1938; n-r — after Desportes, 1938; e, f, s —
after Deshmukh, 1969.

Cephalic end slightly narrowing anteriorly, mouth surrounded by a ring-shaped lip. A thick, rounded sensory papilla, slightly depressed at the apex, on each median line. Between these two papillae are two others, one right and one left, which are less high and more conical, their apex usually truncate and divided into two or three secondary processes. Between each median papilla and each of the two lateral papillae but slightly farther posteriorly is another papilla resembling the latter papillae. Mouth surrounded by 8 papillae, in an arrangement as in *D. medinensis*. A distinct cephalic shield absent.

Tail conical, curved ventrally, ending in a short teatlike process. Anus probably situated near end of tail; intestine reduced, a posterior opening probably absent. The intestine is flattened and displaced toward the uterus, which is filled with embryos.

Embryos 0.400–0.425 mm long and 0.012–0.015 mm wide. Cephalic end curved ventrally, slightly tapering and with a plane surface in the middle of which the buccal funnel is situated. The body becomes conical in its posterior third and ends in a strongly tapering whiplike tail about 0.100 mm long. Cuticle 0.00175–0.002 mm thick, with very fine, indistinct striation with intervals of 0.00175 mm; striation not recognizable on the tail.

Description (after Mackin, 1927, as *D. globocephalus*). Body threadlike, of uniform width throughout. Posterior part of body slightly tapering, ending in a conical spine in both sexes. A small constriction around the cephalic end appears like a neck. Anterior part bluntly rounded, without lips. Eight cephalic papillae symmetrically arranged around the mouth; the largest pair situated dorsoventrally, and the ends of the papillae are directed anteriorly. The next largest pair is lateral, and each papilla of this pair is double, cone-shaped, and contains two nerve endings; the other four papillae are submedian. A pair of cervical papillae about 0.9 mm from the cephalic end on the lateral lines. Lateral fields wide, occupying 1/8 to 1/6 of the circumference of the body. They are not recognizable in total preparations. Median lines markedly reduced.

Male. Length 16–20 mm, width 0.170–0.220 mm. Caudal papillae consisting of a small preanal papilla and a pair of cup-shaped postanal papillae situated ventrolaterally, one before the other. Tail in fixed specimens coiled into a spiral of one to four loops. Genitalia forming a straight duct which begins a quarter of the length of the body from the cephalic end and extends posteriorly to the cloaca. The testis passes gradually into the vas deferens, which fills almost the entire body cavity at the cloaca and then becomes abruptly narrower. Right spicule in the form of a long, narrow needle without wings, 0.8 mm long and 0.005 mm thick, always protruding
255 from the genital cone for more than a third of its length. Left spicule 0.2 mm long and 0.010 mm thick, its proximal third forming a hollow tube widening at the end and the two distal thirds in the form of two tubules connected laterally, the left side united with the proximal end and with the right branch. These two branches become fused into a thin process distally. This spicule was extruded in most specimens. Numerous unicellular glands behind and along the sides of the cloaca, their ducts opening into the cloaca.

Female. Length variable, 30 to 133 mm, width 0.280 to 0.680 mm. The females apparently increase in size as the embryos develop.

The intestinal tract consists of the short muscular part of the esophagus, a much longer glandular part, and the intestine. Buccal cavity or pharynx absent. Mouth more or less triangular, opening directly into the esophagus.

At the connection of the muscular and the glandular part of the esophagus are two wide glands, appearing like two large sacs attached to the outer side. These sacs are partly hollow. Ducts connect the esophagus with the glands. A third, larger, gland is situated at the opposite side of the esophagus, extending posteriorly from a point 0.5 mm from the cephalic end and ending at the connection between the glandular part of the esophagus and the intestine. These three glands are very similar: they have a large nucleus, which is more than 3 mm long in the largest gland. The lumen of the posterior part of the esophagus is almost closed in its greater part and forms a narrow slit. Intestine ending blind in mature females. The posterior end of the intestine in the curve of the tail is attached to the ventral body wall by a band of tissue. Excretory pore situated 1–1.5 mm from the cephalic end, according to the size of the specimen.

Two short ovaries, one at each end of the body; one is wound around the glandular part of the esophagus and extends anteriorly 2 mm from the cephalic end, where it passes into the anterior uterus. The posterior ovary is wound around the posterior end of the intestine and extends to the anus.

Fertilization apparently takes place throughout the uterus. The entire body cavity is occupied by the uteri, which are more or less filled with developing embryos.

The wall of the uterus consists of two layers, a thin outer layer and a nuclear inner layer about 0.003 mm thick.

Vulva situated slightly behind middle of body. Vagina at first directed dorsally toward the left lateral line and then turning anteriorly into the angle between the intestine and the uterus. Vagina and vulva atrophied in females with fully developed larvae; only a short part of the vagina, connected with the vulva, is present.

Description (after Hsü, 1933b, as *D. houdemeri*). Cuticle without transverse striation. Cephalic end narrowing and separated from the body by a constriction. Mouth oval, surrounded by two rudimentary lips which are hemispherical in apical view and triangular in lateral view; they project dorsally and ventrally and have a hemispherical outer margin.

Finger-shaped appendages are present on each side of the cephalic end.

Lateral amphids are visible in apical view, one dorsal and one ventral, and two lateral and four submedian papillae. The dorsal and the ventral papilla are small, weakly protruding, and with double nerve endings. The mouth is followed directly by the muscular part of the esophagus. Its anterior part is enclosed in cuticular outer integument which extends dorsoventrally.

The muscular part of the esophagus is very short and is followed by a long glandular part which begins with a widening of the dorsal esophageal gland and then continues into a narrower part. Width of esophagus 0.290 mm. Intestine 0.070 mm wide, distinctly demarcated from the esophagus. Nerve ring situated immediately behind the anterior widened part of the glandular part of the esophagus.

Female. Length 213 mm, width 0.85 mm. Nerve ring situated 0.93 mm from the cephalic end. Length of esophagus 48.10 mm, muscular part 0.38 mm long, glandular part 47.72 mm. Anterior widened part of glandular part of esophagus 0.05 mm long. Rectum 0.011 mm long. Intestine short, 0.5 mm. Tail conical, pointed, 0.28 mm long. A pair of lateral papillae on the tail. Anus recognizable, but very small. Two thin ovaries; anterior part of anterior ovary beginning about 2.1 mm from the cephalic end, about 7.1 mm long; posterior end of posterior ovary beginning 10.44 mm from end

of tail, about 7.75 mm long. Vagina not recognizable. Branches of uterus containing developed larvae, occupying the greater part of the body cavity. Larvae in the uterus 0.330–0.363 mm long, 0.015–0.018 mm wide; tail 0.28 mm long.

(256)

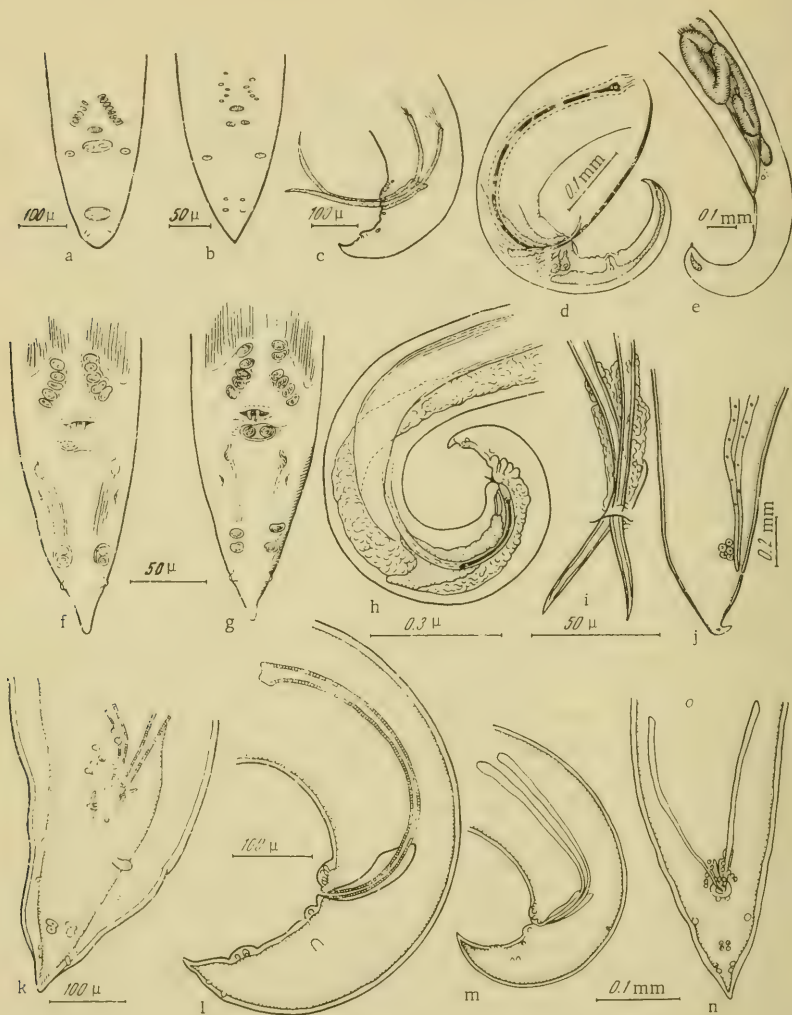


FIGURE 146. *Dracunculus oesophagea* (Polonio, 1859).

Caudal ends: a — after Moorthy, 1937; b, c — after Brackett, 1938; d, e — after Mackin, 1927; f–h — after Desportes, 1938; k, l — after Chabaud, 1960b; m, n — after Deshmukh, 1969. Spicules: i — after Desportes, 1938; j — after Hsü, 1933b.

Description (after Chabaud, 1960b, as *D. doi*).

Male. Length 28 mm, width 0.250 mm. Tail with three coils of a spiral. Cuticle thin and transparent, with transverse striation with intervals of

0.0025 mm. Lateral fields 0.070 mm wide. Cephalic end rounded, with two small lateral processes. Mouth small and rounded, surrounded by an inner ring of 6 large papillae: two single ventral papillae and two double dorsal papillae. Outer ring consisting of 8 large papillae arranged in pairs and two amphids.

Behind the mouth is a chitinized buccal capsule about 0.040 mm long in the form of a cap which envelops the anterior part of the esophagus. The cross section of the buccal capsule is pentagonal, with one dorsal, two lateral, and two lateroventral sides. At the same level is situated the transition from the triradial symmetry of the esophagus (one dorsal lobe and two lateroventral lobes) to bilateral symmetry.

Muscular part of esophagus 0.330 mm long, glandular part with a markedly widened anterior part 0.300 mm long. Excretory pore situated 0.700 mm, nerve ring 0.710 mm, deirids 0.800 mm from the cephalic end.

The first postanal pair of papillae is reduced; the second postanal pair is situated distinctly posteriorly; the terminal subdorsal pair is bifid; each of the group of papillae on the subventral line is situated on a small cuticular ring. The 8 small preanal papillae are arranged in two small longitudinal rows. Tail 0.240 mm long. Spicules simple, ending in a point, about 0.460 mm long. Gubernaculum weakly chitinized, of irregular form, 0.130 mm long.

Description (after Brackett, 1938, as *D. ophidensis*). Mouth 258 surrounded by an inner ring of 6 papillae, the inner lateral papillae most strongly protruding, and an outer ring of double papillae. Esophagus divided into a short muscular part and a long glandular part. Nerve ring surrounding esophagus at the constriction. Cervical papillae situated behind the nerve ring.

259 Male. Length 16 mm, width 0.17–0.20 mm. Length of esophagus 7.7 mm. Nine pairs of caudal papillae, 5 pairs preanal and 4 pairs postanal. The first and second pairs are subventral, the third and fourth pairs ventral, and the fifth to ninth pairs are arranged around the anus. Tail 0.17 mm long. Spicules of almost the same length, 0.554 and 0.523 mm. Anterior end of testis 13.8 mm long, ending 2.7 mm before the cephalic end.

Fé male. Length to 250 mm. Vulva situated in middle or behind middle of body. In a specimen 24.6 mm long, the esophagus was 9.9 mm long, the anterior ovary 5.1 mm, and the vagina 1.4 mm long. Vulva situated 15.1 mm from the cephalic end. Viviparous. The larvae are released through the duct of the uterus and through the body wall at the cephalic end.

First-stage larva: length 0.43–0.45 mm, width 0.016 mm. Cuticle striated; tail long and thin.

Second-stage larva: length 0.62–0.65 mm. Cuticle smooth; tail short and with lobes situated laterally; several unicellular glands at the cephalic end and around the rectum and tail.

Description (after Deshmukh, 1969, as *D. alii*). Cylindrical, milky white nematodes. Cephalic end blunt and rounded, tail curved ventrally, ending in a point. Cuticle smooth. Body uniformly wide except for the tail. Mouth surrounded by a cuticular rim. Two rings of papillae, an outer and an inner, visible in apical view. The two pairs of outer papillae are submedian, of complicated structure. The inner papillae are simple, arranged in three pairs. Amphids situated laterally.

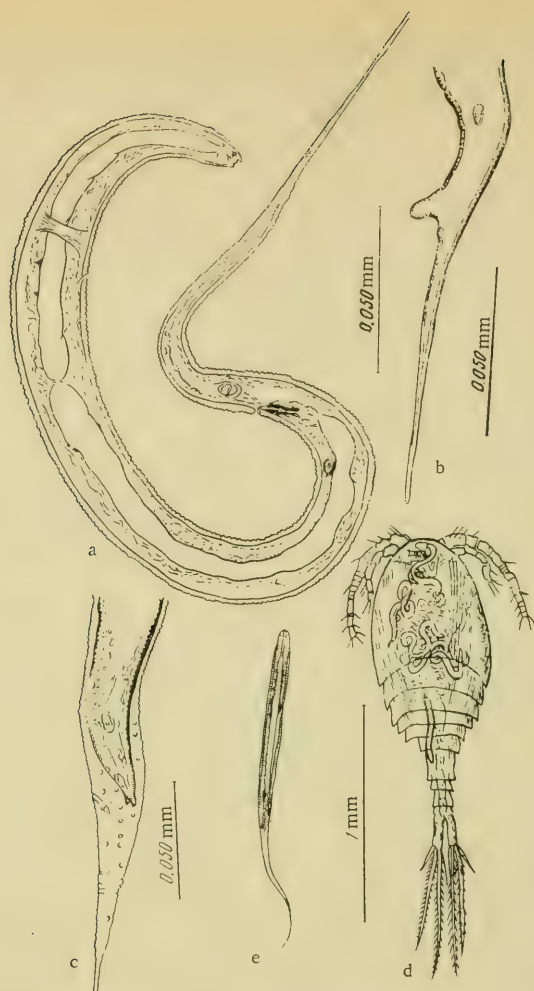


FIGURE 147. *Dracunculus oesophagea* (Polonio, 1859):

a — larva, general view, lateral; b — abnormal process on the tail of a larva; c — posterior end of a 14-day-old larva, lateral; d — Cyclops with larvae 14 days after experimental infection; e — first-stage larva, general view (a—d — after Desportes, 1938; e — after Mackin, 1927).

Male. Length 13.09–24.40 mm, maximum width 0.17–0.28 mm. Width of cephalic end 0.03–0.04 mm. Nerve ring situated 0.34–0.58 mm from the cephalic end. Esophagus consisting of a muscular and a glandular part, the posterior part much wider than the anterior. Length 0.17–0.28 and 0.18–0.29 mm, respectively.

Tail curved ventrally, without caudal wings. Cloaca situated 0.15–0.24 mm from end of tail. Twelve pairs of caudal papillae. Six pairs preanal, one pair situated slightly before the cloaca. Four pairs of papillae

arranged in two groups on each side of the cloaca. The papillae diverge from the medioventral to the ventrolateral position. A further pair of papillae is situated slightly before these groups and lies medioventrally. Six pairs of postanal papillae: one pair medioventral, situated slightly behind the cloaca, the second pair at the first third of the tail, situated laterally, two further medioventral pairs, situated together, between the second pair and the last two pairs, and the last two pairs situated laterally close together. Spicules of similar form and of almost the same length, 0.23–0.30 and 0.22–0.29 mm long. Gubernaculum distinctly divided into two branches 0.05–0.07 mm long and 0.01–0.02 mm wide.

260 Description (after Desportes, 1938, as *D. oesophagea*). Body cylindrical, tapering at both ends. Cuticle with fine transverse striation with intervals of 0.0015 mm. Cephalic end hemispherical, with a round cuticular shield which projects less in young specimens. Mouth with a single lip, almost rounded. Lumen of muscular part of esophagus triradial, one of the sectors ventral; the cuticle surrounding it strongly thickened, forming a ring which is wide in large specimens. The cephalic shield bears 8 papillae in two concentric rings. The first ring consists of four papillae, two median and two lateral; the papillae are low, conical, inclined toward the mouth. The outer ring consists of four large, kidney-shaped, bifid papillae. Amphids present. Cervical papillae situated slightly behind the nerve ring, 0.91 mm from the cephalic end in a female 60 mm long.

Male. Length 11.7–20 mm, width 0.2 mm. Cervical papillae situated 0.65 mm from the cephalic end in a specimen 14.5 mm long, slightly behind the nerve ring. Length of esophagus 9–10.2 mm, muscular anterior part 0.2 mm long.

Tail pointed, twisted, with a variable arrangement of papillae. Five pairs of preanal papillae form two lines curved in opposite directions. A pair of large papillae is situated behind the cloaca. Then follow 4 further pairs of distinct postanal papillae. The first of these pairs consists of two swollen ventrolateral papillae, slightly behind and lateral to which are the openings of the phasmids. The following two pairs of papillae are usually situated close together. The last pair of papillae, which are small and ventrolateral, is situated near the end of the tail. Caudal wings absent. Genitalia represented by a long testis, which at first surrounds the esophagus and continues into the swollen ejaculatory duct. Spicules of almost the same length: left spicule 0.283–0.29 mm long, right spicule 0.297–0.30 mm. Gubernaculum weakly chitinized, pyramidal, 0.065 mm long.

Female. Length 280–437 mm, width 0.3–0.8 mm. Length of esophagus 12–23 mm. Cephalic shield protruding, distinct in lateral view. Circumoral ring distinct. Lateral papillae high, median papillae sometimes double. Cervical papillae situated behind the nerve ring, 1 mm from the cephalic end. Genitalia consisting of two branches of the uterus fused into a single duct, which fills the entire body cavity. The vulva disappears in mature females; only an indistinct spot is visible 182 mm from the cephalic end. Large females are filled with eggs or with motile larvae.

Larvae. Length 0.475 mm, width 0.018 mm, body tapering at the cephalic and particularly at the posterior end, ending in a long tail. Cuticle 0.0017 mm thick, with fine transverse striation with intervals of 0.0016 mm. Distinct papillae present at the anterior end: lateral papillae low, submedian papillae comma-shaped. Dorsally behind the mouth is a distinct spine. Nerve ring

situated 0.065 mm from the cephalic end; a thin duct passes ventrally, ending in the excretory pore. Length of esophagus 0.115 mm, its lumen wide and with hyaline content. Length of intestine 0.160 mm. Rectum 0.022 mm long, anus situated ventrally, 0.3 mm from the cephalic end. Saclike phasmids situated laterally in posterior third of body, 0.012 mm behind the anus. The tail forms about the last third of the body, its end about 0.065 mm long. Mackin (1927) noted that larvae from the uterus lived for about 7 days in saline, but were sluggish. If kept in tapwater or pond water, the larvae were very active for a few days after the females had died. Their activity decreased after 9–10 days, and all died after 12 days. Mackin fed numerous larvae soon after they emerged from the female to various Crustacea: Ostracoda, Copepoda, Cladocera. *Cyclops bicuspidatus* readily swallowed the larvae, which rapidly passed through the wall of the intestine into the body cavity. Other crustaceans did not become infected. *Cyclops* did not suffer from the presence of the nematodes, but if there was a severe infection, the intestine ruptured and the *Cyclops* died. Such a severe infection probably occurs rarely, if at all in nature.

Brackett (1938) also found that larvae from mature females, after entering the water, are in constant motion, remain suspended without sinking to the bottom and remain active for several days. First-stage larvae are characterized by the very long, thin tail. The larvae develop in *Cyclops vireidis*. Twelve to 15 days after entering *Cyclops*, the larvae become infective; they now lose the long, thin tail and grow to a length of 0.62 mm. Their activity decreases but the larvae preserve mobility. The reservoir hosts may be sticklebacks, in which the larvae are present free in the body cavity. Brackett did not observe further development or growth in sticklebacks. Infection of the definitive host, a snake, takes place when it swallows infected *Cyclops*. Desportes (1938) mentioned that the larvae are very active in water in the first few hours. They develop in *Macrocyclus fuscus*. The first molt takes place after 10 days, and the second-stage larva has a very short tail. After 14 days the larvae are 0.510 mm long and the tail 0.040 mm; four pointed appendages are present on the tail.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 69; Brackett, 1938, pp. 353–361; Chabaud, 1960a, pp. 100–103; Deshmukh, 1969, pp. 105–110; Desportes, 1938, pp. 305–326; Hsü, 1933, pp. 101–118; Mackin, 1927, pp. 91–94; Mirza, 1929, pp. 129–156; 1957, pp. 44–47; Mirza and Basir, 1938, pp. 26–32; Mirza and Roberts, 1957, pp. 40–43; Moravec, 1963, pp. 378–379; 1966; pp. 281–283; Neumann, 1895, pp. 123–127; Travassos, 1934, pp. 235–237.

SUBFAMILY AVIOSERPENTINAE WEHR AND CHITWOOD, 1934 EMEND. CHITWOOD, 1935

Synonym: Avioserpensinae Wehr and Chitwood, 1934

Historical review

The subfamily was established in 1934, although the authors only had fragments of females. The authors established a new genus and the new

subfamily, Avioserpensinae, because of the absence of the circumoral chitinized ring which is characteristic for *Dracunculus*, to which the new species is closely related.

Chitwood (1935) changed the name Avioserpensinae to Avioserpentinae Wehr and Chitwood, 1934, but did not change the diagnosis. Yamaguti (1961b) recognized the name Avioserpentinae Chitwood, 1935 and made the name Avioserpensinae a synonym.

262. Skrzabin, Shikhobalova, Sobolev, Paramonov and Sudarikov (1954) disregarded the change of name and named the subfamily Avioserpensinae Wehr and Chitwood, 1934.

To avoid confusion, Supryaga (1967a) suggested using the name Avioserpentinae Wehr and Chitwood, 1934, emend. Chitwood, 1935.

Diagnosis. *Dracunculidae*. Cephalic end with 14 papillae arranged in two concentric rings. Amphids situated between the rings. Cephalic shield present, but a distinct circumoral ring absent. Cervical papillae oblong. Esophagus consisting of a muscular anterior and a glandular posterior part. Anterior part markedly shorter than posterior part. Spicules well developed. Gubernaculum strongly chitinized. Anus and vulva absent in the adult female. Viviparous.

Type genus: *Avioserpens* Wehr and Chitwood, 1934.

Genus *Avioserpens* Wehr and Chitwood, 1934

Synonym: *Oshimaia* Sugimoto, 1934

Historical review

The genus *Avioserpens* was established for a species from the subcutaneous tissue of the neck and the oral mucosa of *Egretta garzetta* in North America; the authors named it *Avioserpens denticulophasma*. Although they had only fragments of females 590.0 mm long (a cephalic and two caudal ends), the authors established for the genus the new subfamily Avioserpensinae.

Wehr (1934) recorded *Anas fuligula* from Florida as the definitive host of this species. Sugimoto (1934b) established the genus *Oshimaia* for the species *Oshimaia taiwana*, which he had described in 1919 from a submaxillary tumor and the subcutaneous tissue of the femur of ducklings in Taiwan. Sugimoto placed the new genus in the family Philometridae. In 1935, apparently because of Wehr's statement that the parasite from *A. fuligula* is identical with *Avioserpens denticulophasma* from *Egretta*, Chitwood made *A. denticulophasma* a synonym of *Avioserpens taiwana* (= *Oshimaia taiwana* (Sugimoto, 1919)) without a differential diagnosis, and made *Avioserpens denticulophasma* and the genus *Oshimaia* Sugimoto, 1934 synonyms of *Avioserpens taiwana*.

However, the names *Oshimaia taiwana* (Sugimoto, 1919) and *Oshimaia* Sugimoto, 1934 appeared in the literature independently until 1950.

Chabaud, Campana, and Truong-Tang-Ngok (1950) described nematodes from tumors in the submaxillary region of young domestic ducks from

South Vietnam which they named *Oshimaia taiwana* (Sugimoto, 1919). After comparison of these forms with *Avioserpens galliardi* Chabaud and Campana, 1949, the authors concluded that they belong to the same genus. Chabaud et al. (1950) established that the genera
263 *Avioserpens* Wehr and Chitwood, 1934 and *Oshimaia* Sugimoto, 1934 are identical and that they belong to the family Dracunculidae Leiper, 1912. Since the genus *Avioserpens* was described before the genus *Oshimaia*, the name *Avioserpens* Wehr and Chitwood, 1934 has priority.

Although Chabaud, Campana, and Truong-Tang-Ngok (1950) had come to the same conclusion as Chitwood (1935), later authors (Skrjabin et al., 1954; Yamaguti, 1961b) quoted only Chabaud et al. (1950) on the identity of the general *Avioserpens* and *Oshimaia*. The authors designated *A. denticulophasma* as the type species of the genus *Avioserpens* Wehr and Chitwood, 1934, retaining *A. taiwana* in the genus among other species. Yamaguti (1961b), however, stated that *A. denticulophasma* is a synonym of *A. taiwana*. They apparently considered Chitwood's conclusion that the two species are identical as not sufficiently substantiated.

After an analysis of the composition of the genus *Avioserpens*, and of the morphology of the parasite, the definitive hosts, the localization, and the geographical distribution, Supryaga (1967a) agreed with Chitwood that *A. denticulophasma* and *A. taiwana* are identical and made *A. denticulophasma* a synonym of *A. taiwana*.

Chabaud and Campana (1949) described *Avioserpens galliardi*, which they found in an aponeurosis of the upper part of the esophagus of *Egretta garzetta* in the Eastern Pyrenees. The species was described from one male and one female.

Singh (1949b) described *Avioserpens multipapillosa* from the subcutaneous tissue of the neck of *Ardeola grayi* from India. He had only one female. Singh did not know the description of *A. galliardi* Chabaud and Campana, 1949, and he therefore compared *A. multipapillosa* only with *A. denticulophasma* and *A. taiwana*. He distinguished *A. multipapillosa* from *A. taiwana* by its smaller size and by the ventrally curved tail. However, the length of the female of *A. multipapillosa* cannot be used as a specific character because the specimen was immature, and a curved tail is present also in other species of *Avioserpens*. Supryaga (1967b) reviewed the descriptions of *A. galliardi* and *A. multipapillosa* and because of the absence of distinct differences between these species, their similar localization (subcutaneous tissue of the neck), the same definitive hosts, and the wide distribution of *A. galliardi* in many Ciconiiformes in Europe and Asia, concluded that *A. galliardi* and *A. multipapillosa* are identical. The descriptions of both species were published in 1949, but Chabaud and Campana's study appeared a few months earlier, and the authors had males, while Singh had described his species from a single immature female. Supryaga (1967b) therefore suggested retaining *A. galliardi* and making *A. multipapillosa* a synonym of it. His arguments seem convincing. *Avioserpens bifidus* was described by Olsen (1952a) from *Clangula islandica* in North America. The
264 nematodes were found at the base of the tongue, only fragments of mature females (one cephalic end and two caudal ends) 590 mm long; a male was not

found. Olsen distinguished his species from *A. denticulophasma* and *A. multipapillosa* by the form of the mouth, which is a transverse slit in *A. bifidus*, while it is rounded in the other species, and also by the form of the phasmids and the size of the larvae.

After examination of the form of the mouth in *A. galliardi* and *A. mosgovoyi*, Supryaga (1967b) found that this is not a constant specific character; Turemuratov (1965) gave a drawing of the cephalic end of *A. galliardi*, in which the mouth is shown as a transverse slit. Supryaga (1967b) concluded that the characters used by Olsen are not sufficient for the establishment of a new species. Furthermore, Olsen did not compare his species with the descriptions of *A. galliardi* and *A. taiwana*. The size of the larvae of *A. bifidus* can also not be used as a specific character, since the length of the larvae does not differ much from that of other species of the genus.

Because of the above, the localization and the definitive host, and the almost identical size of the females of *A. bifidus* and *A. taiwana*, Supryaga (1967b) concluded that they are identical; *A. taiwana* was published first and so he made *A. bifidus* a synonym of it.

Mawson (1957) described a male and a female of a new species *Avioserpens*, *A. nana*, found in the subcutaneous tissue of *Ardea herodias* from Canada. He distinguished it from other species of the genus by the smaller size of the female. However, since this female was immature, its length cannot be used as a specific character. Supryaga (1967b) stated that because of the localization (subcutaneous tissue of the neck), its definitive host (*Ardea*), and its geographical distribution, *A. nana* is closely related to *A. galliardi*. The length of the body, tail, and gubernaculum is very similar in the two species. Supryaga (1967b) considered as a specific difference the different length of the spicules in the two species: 0.240 mm in *A. nana* and 0.330–0.446 mm in *A. galliardi* although Mawson's male specimen was probably immature. Mawson did not mention the pigmentation or the length of the intestine of the male of *A. nana*, according to which its age could have been determined. Supryaga assumed that the validity of *A. nana* is doubtful and that *A. nana* is closely related to *A. galliardi*. We agree with his arguments and consider *Avioserpens nana* as a synonym of *A. galliardi*.

During a study of the helminth fauna of birds in the Azov estuaries in the Krasnodar Territory in 1965–1967, Supryaga found in 12 out of 148 *Fulica atra* specimens of *Avioserpens* which he described as *Avioserpens mosgovoyi* Supriaga, 1965. *A. mosgovoyi* differs distinctly from *A. galliardi* in the structure of the gubernaculum, the form and smaller size of the spicules, and in its hosts (*A. mosgovoyi* parasitizes in Rallidae and Colymbiformes, *A. galliardi* in Ciconiiformes). In its localization, *A. mosgovoyi* closely resembles
265 *A. taiwana*, a parasite of domestic ducks in South Vietnam, which also causes tumors in the submaxillary region. However, according to experimental data, (3 five-day-old birds became infected out of 12 mallards of different age), Supryaga considered the mallard as only a facultative host of *A. mosgovoyi*.

In the original description (1965a) the author gives only minor characters which distinguish his species from *A. taiwana*: the greater length

of the larvae (0.448—0.500 mm in *A. mosgovoyi* and 0.420 mm in *A. taiwana*) and the greater size of the female (88.0 cm in *A. mosgovoyi* and 19.5 cm in *A. taiwana*). Supryaga (1967b) stated that "the length of the body is apparently a definite character for the distinction of species of the genus. However, the length of females of *A. mosgovoyi* increases 30—45 times from their fertilization to maturation of the larvae in the uterus and their discharge. A comparison of the size of first-stage larvae of the species of *Avioserpens* shows that their length cannot be used for the distinction of species of the genus."

In view of the above, *A. mosgovoyi* is probably not a valid species, but the author thinks that only comparison of material from Vietnam and the USSR will make it possible to decide this question, and we therefore consider *A. mosgovoyi* provisionally as a valid species.

Yamaguti (1961b) recognized six species in the genus *Avioserpens*: the type species *A. denticulophasma* Wehr and Chitwood, 1934, *A. bifidus* Olsen, 1952, *A. galliardi* Chabaud and Campana, 1949, *A. multipapillosa* Singh, 1949, *A. nana* Mawson, 1957, and *A. taiwana* (Sugimoto, 1919).

We recognize only three species in the genus *Avioserpens*: *A. galliardi*, *A. taiwana*, and *A. mosgovoyi*.

Diagnosis. *Avioserpentinae*. Cephalic end with a shield, without a distinct circumoral chitinized ring. Fourteen pairs of cephalic papillae arranged in two concentric rings. Inner ring with two interolateral papillae; outer ring with four dorsoventral double papillae and eight paired ventral, lateroventral, and dorsal papillae. Amphids situated between the two rings of papillae, immediately behind the interolateral papillae. Mouth round or oval. Esophagus consisting of a short muscular anterior part and a long glandular posterior part. The glandular part has a swollen anterior part separated from the other part by the nerve ring. Cervical papillae weakly projecting. Intestine tubular. Mature females several tens of times larger than males.

Male. Genital papillae postanal. Tail curved ventrally. Spicules of equal length, strongly chitinized. The narrowed distal end of the gubernaculum has spines on the lower side; gubernaculum chitinized. Genital duct single; testis and ejaculatory duct gradually merging.

Female. Vulva situated slightly behind middle of body, atrophied in adults. Two uteri, amphidelphic in adults and sometimes opistodelphic in young females. In mature females the uterus is saclike and fills the entire body cavity. The larvae in the uterus of mature females have a long, awl-shaped tail. Infective larvae have a short tail with three spines.

Mature specimens parasitize in the subcutaneous tissue or in an aponeurosis in the upper part of the esophagus of birds. The larvae develop in the body cavity of Copepoda. Reservoir hosts sometimes have a part in the life cycle.

Type species: *Avioserpens taiwana* (Sugimoto, 1919) Chitwood, 1935.

Avioserpens taiwana (Sugimoto, 1919) Chitwood, 1935
(Figure 148)

Synonyms: *Filaria taiwana* Sugimoto, 1919; *Oshimaia taiwana* (Sugimoto, 1919); *Avioserpens denticulophasma* Wehr and Chitwood, 1934; *A. bifidus* Olsen, 1952

Hosts: *Anas platyrhynchos*, *A. fuligula*, *Anhinga anhinga*, *Clangula* (= *Glaucionetta*) *islandica*.

Localization: subcutaneous tissue; tumors under the lower jaw and under the mucosa of mouth and pharynx.

Distribution: Taiwan, Vietnam, USA.

Description (after Sugimoto, 1934a, as *Oshimaia taiwana*).

Male unknown.

Female. Length 100–240 mm, width 0.8 mm. Cuticle smooth. A short, narrow vestibule between esophagus and mouth. Length of cylindrical part of esophagus 1.3 mm. Nerve ring surrounding posterior part of esophagus 1 mm from the cephalic end. Anus atrophied. Embryos thin, white, 0.390–0.420 mm long and 0.156–0.020 mm wide. After passing into the outer environment the embryos are 0.420–0.510 mm long and 0.021 mm wide. Tail long.

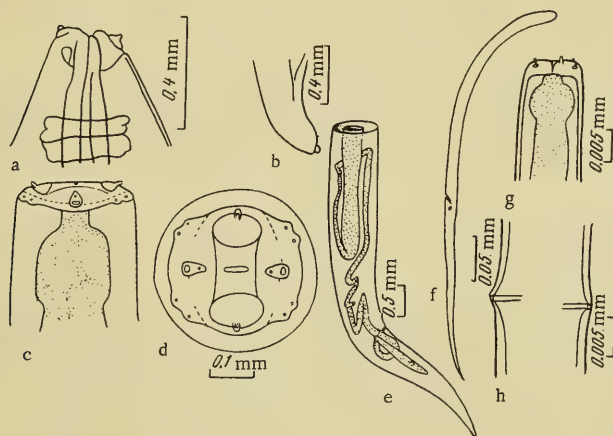


FIGURE 148. *Avioserpens taiwana* (Sugimoto, 1919):

a — cephalic end; b — caudal end; c — cephalic end of female, lateral; d — same, apical; e — posterior end of female, lateral; f — first-stage larva; g — anterior end of larva; h — phasmids of first-stage larva, ventral (a, b — after Sugimoto, 1934b; c–h — after Olsen, 1952a).

267 Description (after Wehr and Chitwood, 1934, as *A. denticulophasma*). The authors only had fragments of females (one cephalic and two caudal ends).

Female. Width 0.750 mm. Mouth rounded, enclosed in a delicate membrane with radial fibers. Esophagus consisting of a short, narrow muscular anterior part and a relatively large glandular part; boundary between the two parts indistinct. Intestine narrow, ending blind; anus rudimentary. Tail conical, curved dorsally. Vulva not found; two ovaries, one at each end of the body. Viviparous.

Larvae from the uterus. Length 0.400–0.450 mm, width 0.143–0.16 mm. Head small, conical, with dorsal processes. Tail pointed, curved ventrally. Phasmids large, postanal, with serrated margin.

Description (after Olsen, 1952a, as *A. bifidus*). The author only had fragments of two mature females 700 mm long, including one cephalic end.

Female. Width 0.580 mm at the anterior glandular widening of the esophagus and 0.835 mm near the posterior end of the second part of the esophagus. Cuticle with delicate transverse striation on the whole body, with 4 or 5 wide transverse stripes covering part of the body from both sides near the posterior end of the esophagus. Excretory pore not found.

Width of head 0.313 mm, dorsoventral width 0.348 mm. Mouth forming a transverse slit 0.068×0.023 mm large, situated on a square area 0.103 mm long, and with oval parts 0.070×0.117 mm contiguous dorsally and ventrally. Fourteen cephalic papillae. The interodorsal and interoventral papillae are projecting, with a double inner part with a striated stalk.

Muscular anterior part of esophagus about 0.174 mm long and 0.150 mm wide; anterior glandular swelling 0.916 mm long and 0.406 mm wide; glandular posterior part of esophagus about 0.0075 mm long. Intestine not recognizable.

Tail sharply curved, with a distinct fold at the curvature. Anus not found and the direction of the curvature of the tail could therefore not be determined. End of tail oblique, with a narrowing of the parenchyma before the end. Tail markedly tapering from a point 0.116 mm from the end.

Vagina and vulva not found. An ovary present in the posterior part of the body, its end 0.882 mm from end of tail. Uterus filled with larvae. Viviparous.

First-stage larvae from the uterus 0.465–0.512 mm long and 0.013–0.0143 mm wide; tail 0.132–0.156 mm long, pointed, straight. Phasmids large, postanal, with smooth margins. Cephalic end with a conical dorsal spine; 4 cephalic papillae. Esophagus with the anterior and posterior bulbs characteristic for the genus.

Life cycle not established. Sugimoto (1934a) stated only that he found larvae of *A. taiwana* in the body cavity of *Cyclops* sp., but did not describe them.

- 268 References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 70; Chabaud and Campana, 1949, pp. 67–76; Chabaud, Campana and Truong-Tang-Ngok, 1950, pp. 335–339; Chitwood, 1935, pp. 51–54; 93–96; Olsen, 1952a, pp. 150–153; Sugimoto, 1919; 1934a, pp. 261–266; Wehr, 1934, p. 11; Wehr and Chitwood, 1934, pp. 10–11; Yamaguti, 1961b, p. 328.

Avioserpens galliardi Chabaud and Campana, 1949
(Figures 149–151)

Synonyms: *Avioserpens multipapillosa* Singh, 1949;
A. nana Mawson, 1957

Hcsts: *Egretta garzetta*, *Ardeola greyii*, *A. herodias*.

Localization: aponeurosis in upper part of esophagus, under the skin, in the neck.

Distribution: Europe, Canada, India, USSR.

Historical review

Avioserpens galliardi was described from a male and a female found in an aponeurosis in the upper part of the esophagus of *Egretta garzetta* in the Eastern Pyrenees.

A. galliardi is widely distributed in the USSR, and helminthologists confirmed the validity of the species and considerably increased the range of its definitive hosts. Shakhtakhtinskaya (1951) described *Petroviprac-ta vigissi* from the thoracic cavity of a mallard (Azerbaijan), for which she established a new genus. Chabaud and Campana-Rouget (1952) compared the posterior end of the male of *P. vigissi* with that of the specimen of *A. galliardi* described in 1949 and concluded that the two species are identical. Supryaga (1967b) agreed. Shakhtakhtinskaya thus first recorded *A. galliardi* in the USSR. In a study of parasites of fish-eating birds in the Astrakhan reserve, Kosupko (1963) found two males of *A. galliardi*, in *Egretta garzetta* on the esophagus and in a mallard on the trachea. The wide distribution of *A. galliardi* in the Aral area is reported by Turemuratov (1965), who found this species in *Ardea cinerea*, *A. purpurea*, *Egretta alba*, *E. garzetta*, and *Botaurus stellaris*. In a study of birds in the lower reaches of the Ob, Daiya (1967) found a male of *A. galliardi* in *Mergus merganser* and another in *Gavia stellata*; the nematodes were localized in the subcutaneous tissue of the neck.

In the Azov estuaries in the Krasnodar Territory Supryaga (1967b) found this species in the subcutaneous tissue of the neck in *Ardea purpurea*, *Egretta garzetta*, and *Botaurus stellaris*, so that birds of three families are definitive hosts of *A. galliardi*: Ardeidae, Anatidae, and Gaviidae.

Description (after Chabaud and Campana, 1949).

Male. Length 8.7 mm, width 0.18 mm. Body forming two coils of a spiral. Transverse striation present on the whole body, very fine and dense. Cervical papillae very small, situated 0.48 mm from the cephalic end, 0.09 mm behind the nerve ring. Length of muscular part of esophagus 0.125 mm, of glandular part 0.22 mm in the widened anterior part and 3.2 mm in the other part. Tail narrow, 0.3 mm long. Because of bad fixation, the phasmids and caudal papillae were not visible. Spicules 0.445 and 0.410 mm long. Gubernaculum strongly chitinated, smooth, 0.15 mm long.

Female. Length 210 mm, width 0.68 mm. Cuticle with fine transverse striation which is almost absent in the middle of the body but distinct in the posterior part, where the intervals are 0.001–0.002 mm. Cephalic end separated from the body by a marked constriction situated 0.15 mm from the cephalic end. Mouth rounded, small, slightly protruding. Circumoral ring absent. Lumen of esophagus triangular, its apex ventral. Cephalic shield with 14 papillae in two concentric rings. Two amphids situated laterally between the two rings of papillae, forming two distinct oval parts; the inner of these parts bearing an interolateral papilla. Median papillae large. Ventral and dorsal papillae double. They are situated on elevations which are clearly visible in lateral view. The lateral

papillae of the outer ring form two pairs on each side; the lateral papilla is slightly larger than the other papilla. Cervical papillae hemispherical and weakly protruding, situated 1.6 mm from the cephalic end. Tail ending in a small, pointed appendage about 0.01 mm long. Length of tail 0.75 mm.

(269)

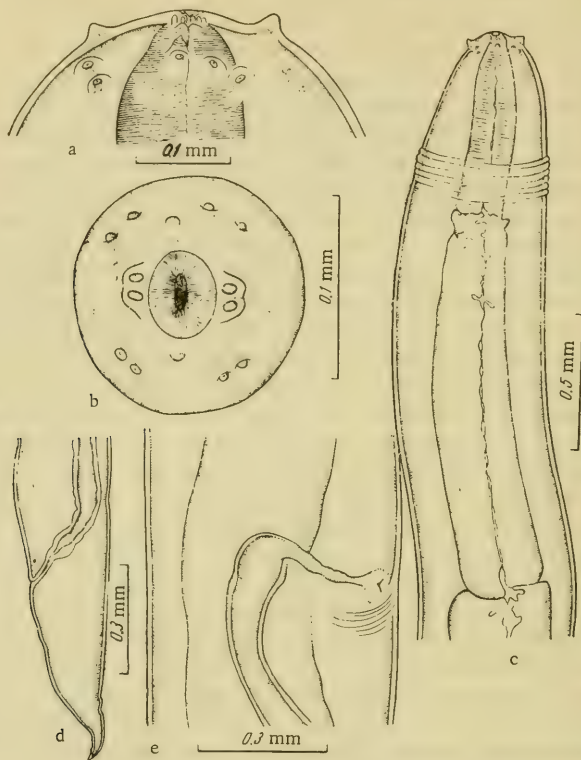


FIGURE 149. *Avioserpens galliardi* Chabaud and Campana, 1949:

a — cephalic end, lateral; b — same, apical; c — anterior end; d — caudal end of female, lateral; e — region of vulva, lateral (after Chabaud and Campana, 1949).

A simple papilla situated at the anus. Phasmids not found. Length of muscular part of esophagus 0.35 mm. Glandular part divided by the nerve ring into a swollen anterior part, which is oval and 0.85 mm long, and a posterior part 62 mm long. The intestine is recognizable only in the posterior region, where it narrows sharply before the anus. Position of vulva not determined. Uterus, filled with larvae, occupying almost the entire body cavity; it curves slightly above the anus in the caudal part and ends 3.8 mm before the cephalic end.

Description (after Singh, 1949b, as *A. multipapillosa*).

Female (immature). Length 105 mm, width 0.12 mm. The widening of the glandular part of the esophagus distends the cephalic end in the form of a cupola. Cephalic end with 7 pairs of distinct papillae, two pairs

submedian, one pair lateral, and two pairs on each side between the lateral and submedian papillae. Esophagus divided into a short muscular anterior part 0.186 mm long and a glandular swelling 0.688 mm long and 0.658 mm wide. Intestine thin, rectum short. Tail 0.68 mm long, tapering, curved ventrally. Vulva indistinct, situated 12.25 mm from the cephalic end, dividing the body at the ratio of 1:7.5.

(270)

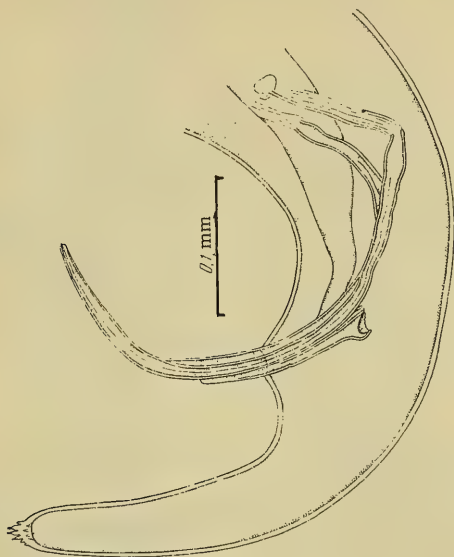


FIGURE 150. *Avioserpens galliardi* Chabaud and Campana, 1949.

Caudal end of male (after Chabaud and Campana, 1949).

Description (after Mawson, 1957a, as *A. nana*). Cuticle with fine annulation. Cephalic papillae more distinct in females, two situated dorsally and two ventrally near the mouth; outer ring consisting of a pair of lateral papillae and 4 pairs of submedian papillae. Amphids not found.

Esophagus consisting of a short anterior and a longer, widened posterior part.

Male. Length 7 mm. Length of anterior part of esophagus 0.140 mm, of posterior part 0.700 mm. Tail long, tapering sharply to a point. At its narrowing there are 5 ventral spines, and two accessory spines at the end. Tail 0.300 mm long. Anal and caudal papillae absent. Both spicules 0.240 mm long, their proximal third wider. Gubernaculum 0.150 mm long, with widened proximal part.

Female. Length 27.5 mm. Length of anterior part of esophagus 0.150 mm, of posterior part 0.500 mm. Vulva and larvae not found. Tail long, tapering, then narrowing abruptly, ending in a point. Tail 0.400 mm long.

Life cycle (after Chabaud and Campana, 1949). Larvae from the uterus of *A. galliardi* placed in physiological saline and in fresh water were very active and remained alive for 2 days. First-stage larva

0.540 mm long, 0.018 mm wide. Length of esophagus 0.16 mm; ratio of length of esophagus to length of larva 3:4. Nerve ring situated 0.077 mm, anus 0.37 mm from the cephalic end. Twelve hours after the larvae had been taken from the uterus, they were placed together with *Cyclops*; 24 hours later, three of the *Cyclops* examined contained a larva with a pointed tail, which is characteristic for *A. galliardi*. Twelve hours after infection, one out of 6 *Cyclops* infected contained two larvae which had molted (the long thin tail was absent).

(270)

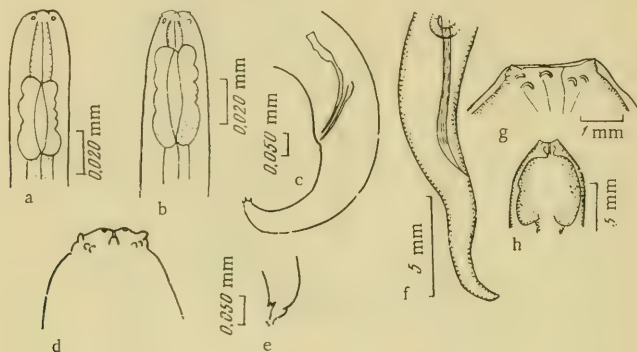


FIGURE 151. *Avioserpens galliardi* Chabaud and Campana, 1949:

a - anterior end of male; b - anterior end of female; c - posterior end of male, lateral; d - cephalic end of female; e - caudal end of male; f - caudal end of female, lateral; g - cephalic end; h - anterior end (a-e - after Mawson, 1957a; f-h - after Singh, 1949b).

- 272 A larva taken from a *Cyclops* after 15 days was 0.480 mm long, and the tail showed the characteristic spines. The esophagus was 0.24 mm long.

References: Daiya, 1967, pp.142-145; Kosupko, 1963, pp.158-159; Shakhtakhtinskaya, 1951, p.163; Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.70; Supryaga, 1967b, pp.116-165; Turemuratov, 1965, p.102; Chabaud and Campana, 1949, pp.67-76; 1952, p.482; Chabaud, Campana and Truong-Tang-Ngok, 1950, pp.335-339; Mawson, 1957a, pp.213-219; Singh, 1949b, pp.54-55; Yamaguti, 1961b, p.329.

Avioserpens mosgovoyi Suprjaga, 1965
(Figures 152-156)

Hosts: *Fulica atra*, *Podiceps cristatus*, *P. ruficollis*, *P. griseigena*.

Localization: subcutaneous tissue.

Distribution: USSR.

Description (after Supryaga, 1965a). Large nematodes, slightly thinner toward the cephalic and caudal end. Body threadlike, white. Cuticle thin, transparent, with delicate transverse striation. Mouth simple, without a cuticular ring or other formations, rounded, or short-oval.

(273)

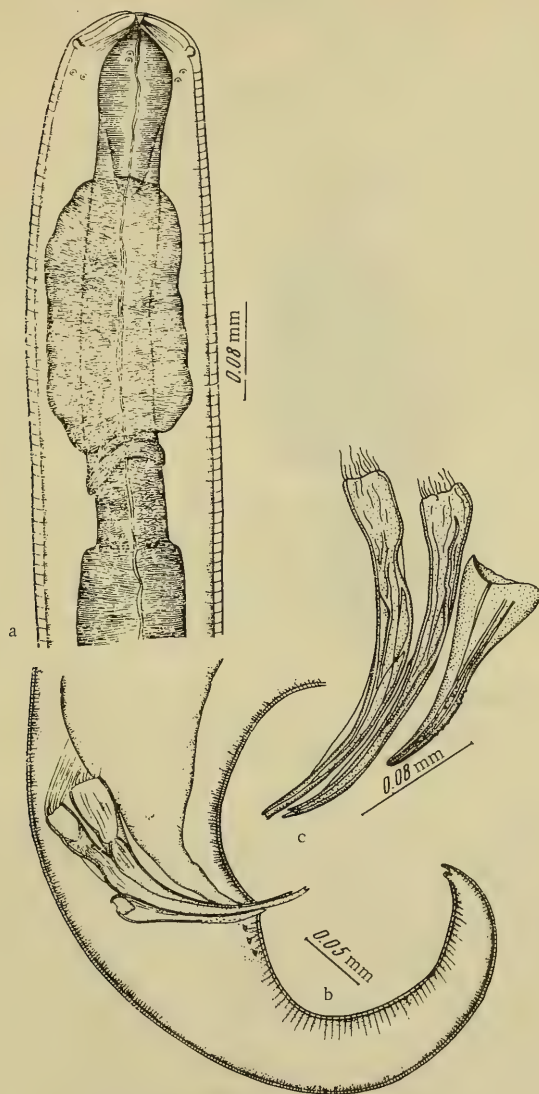


FIGURE 152. *Avioserpens mosgovoyi* Supryaga, 1965:

a — anterior end of male, lateral; b — caudal end of male, lateral; c — spicules and gubernaculum (after Supryaga, 1967a).

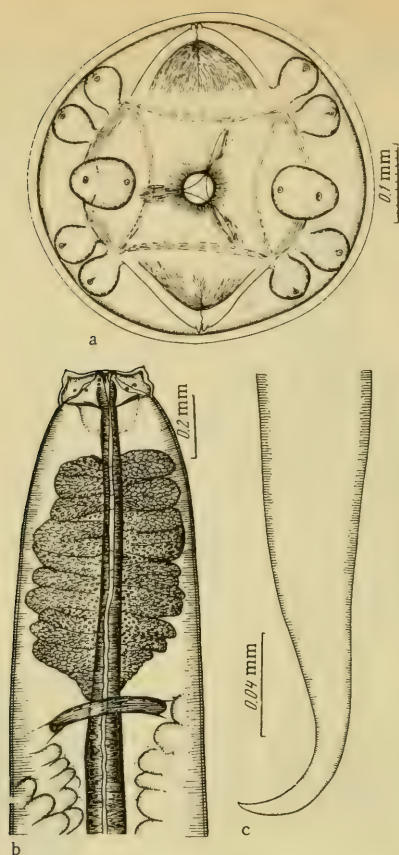


FIGURE 153. *Avioserpens mosgovoyi* Supryaga, 1965:

a — cephalic end, apical; b — anterior end of female, lateral; c — caudal end of female (after Supryaga, 1967a).

Fourteen cephalic papillae in two concentric rings: inner ring consisting of two interolateral papillae, outer ring of four double dorsoventral papillae and eight paired ventral, lateroventral, laterodorsal, and dorsal papillae. Amphids situated between the two rings of papillae, behind the interolateral papillae. Esophagus consisting of a short muscular anterior part and a long glandular posterior part. Glandular part divided by the nerve ring into a swollen anterior and an elongate, narrower posterior part. Intestine tubular, long and narrow.

Male. Length 6.8–14.0 mm, maximum width 0.135–0.209 mm. Mouth passing into the distinct buccal cavity, which is 0.010 mm long and 0.015 mm wide. Muscular part of esophagus 0.085–0.132 mm long, with thick walls and a distinct sinuous lumen. Width of muscular part of esophagus 0.040–0.052 mm. Glandular part 0.110–0.220 mm long and 0.070–0.145 mm wide. Posterior elongate part of glandular part of esophagus 1.40–2.31 mm long.

Nerve ring surrounding constricted part of glandular part of esophagus, situated obliquely, 0.250–0.350 mm from the cephalic end.

Intestine 5.7 to 11.3 mm long, according to the length of the body; its width and pigmentation decrease with age, and it is difficult to see on the background of the genital duct, around which it is wound in the form of a narrow light brown ribbon.

Genital duct single, 5.45–11.331 mm long. Spicules reddish brown, strongly chitinized, curved ventrally. Proximal end of spicules widened.

273 From this end extend two dark brown stylets, which end in small processes at the distal end. Between the stylets extends a light brown, delicate chitinized membrane which forms a canal along the spicules, narrowing
274 distally. Spicules of almost the same length, right spicule projecting slightly anteriorly, 0.170–0.190 mm long, left spicule 0.165–0.185 mm long. Maximum width of spicules at the proximal end 0.024 mm. The spicules narrow 0.04 mm from the proximal end, forming a constriction 0.016 mm wide, and then widen again to 0.020 mm. Width of spicules at the distal end 0.004 mm. Gubernaculum reddish brown, strongly chitinized, 0.080–0.108 mm long, its proximal end 0.020–0.030 mm wide; the gubernaculum narrows to 0.10–0.15 mm distally. The narrow part of the gubernaculum bears distinct spines on the lower surface.

Tail conical, curved ventrally, ending in three spines; the two ventral spines 0.004 mm long, the dorsal spine 0.008 mm. Each spine ends in papillae which are supplied with nerve endings. Four pairs of postanal sessile papillae.

Female. Length 880.0–1130.0 mm, maximum width 0.8–1.0 mm. Muscular part of esophagus 0.198–0.286 mm long, 0.015–0.050 mm wide. The glandular part of the esophagus consists of a swollen anterior and an elongate, narrower posterior part separated by the nerve ring. Length of swollen glandular part 0.470–0.960 mm, width 0.430–0.600 mm.

Nerve ring situated 0.743–1.950 mm, cervical papillae 1.14 mm from the cephalic end.

The entire body cavity is occupied by the wide, saclike uterus filled with larvae, which are 0.450–0.500 mm long.

Life cycle, after Supryaga (1965b). The intermediate hosts of *A. mosgovoyi* are species of *Cyclops* and *Diaptomus*.

Larvae which have passed out of the uterus have a long awl-shaped process at the posterior end (0.048–0.064 mm) and a distinctly transversely
275 striated cuticle. Length 0.440–0.510 mm, maximum width 0.012–0.016 mm. Length of esophagus 0.120 mm, of intestine 0.140 mm. Cephalic end rounded, mouth terminal. Length of tail 0.094 mm. The larvae are active in water, remaining mobile for 4–6 days at 20–25°.

A few hours after entering the intestine of *Cyclops*, the larvae pass into the body cavity, where they develop further.

At a water temperature of 22–29° the first molt takes place 6–8 days after infection of *Cyclops*; the larvae do not discard the sheath. Second-stage larvae are little active; cuticle delicate, smooth; the awl-shaped process at the tail is lost; their size decreases slightly: length 0.439–0.499 mm, width 0.016–0.022 mm. Length of esophagus 0.135–0.220 mm, length of intestine 0.1800–0.2025 mm. Nerve ring and excretory pore distinct, situated 0.0728–0.0810 and 0.0810–0.0864 mm, respectively, from the cephalic end.

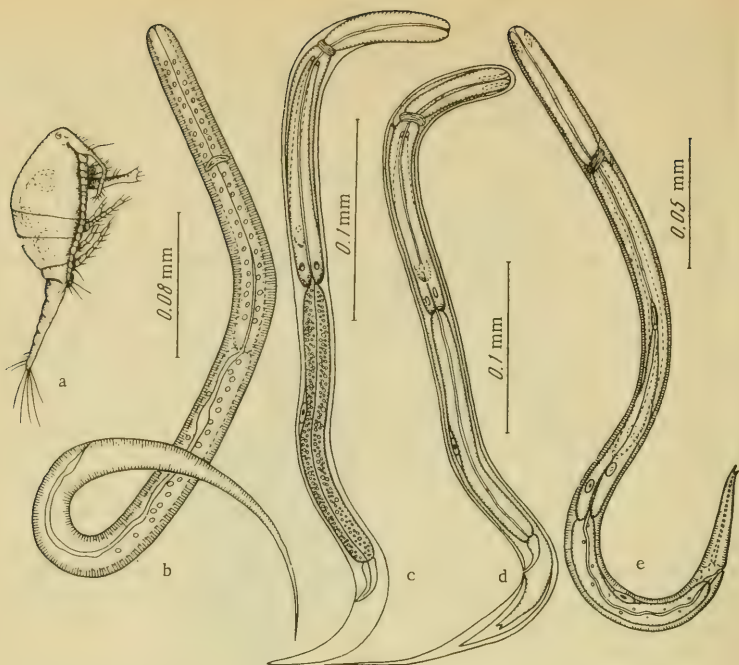


FIGURE 154. *Avioserpens mosgovoyi* Supryaga, 1965:

a — larvae in *Cyclops*; b — first-stage larva; c — second-stage larva; d — third-stage larva from *Cyclops*; e — third-stage larva from the reservoir host 74 days after infection, (after Supryaga, 1967a).

The second molt takes place after 2–3 days. The third-stage larvae are active and grow rapidly without any morphological changes; their distinguishing character is the presence of three spines (two lateral and one dorsal) at the end of the tail. Third-stage larvae remain viable for 4 months in *Cyclops* (Supryaga, 1967a). At this stage the larvae are 0.389–0.478 mm long and 0.019–0.022 mm wide. Cuticle with delicate transverse striation. Cephalic end with two amphids and four double papillae. Nerve ring situated 0.078–0.081 mm from the cephalic end. Length of esophagus 0.162–0.262 mm. At the base of the esophagus are three long glands which open into the esophagus near the nerve ring. Tail 0.040–0.067 mm long. Genital primordium oval, 0.013–0.019 mm long, with a large nucleus, situated 0.04–0.054 mm behind the end of the esophagus.

Supryaga (1967b) found that the life cycle of *A. mosgovoyi* includes reservoir hosts: fingerlings of roach, gobies, and sticklebacks and dragonfly larvae, in which the larvae do not change morphologically but remain viable for 2–2.5 months.

After entering the stomach of the definitive host, the larvae of *A. mosgovoyi* migrate into the serosa and mesentery, where the third molt takes place 4–5 days after infection. The fourth-stage larvae differ

according to their sex. Length of male larva 0.970 mm, of female larva 1.710 mm. The esophagus consists of a muscular and a glandular part, and a glandular mass is formed above the nerve ring. The tail ends in five spines. The male larvae have a distinct preanal widening in which the spicules are situated, which are curved ventrally and 0.035–0.040 mm long. Gubernaculum 0.020–0.025 mm long.

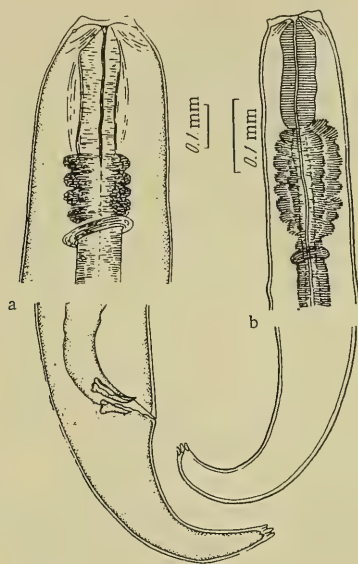


FIGURE 155. *Avioserpens mosgovoyi* Supryaga, 1965:

a — anterior and posterior end of fourth-stage larva (male) 7 days after infection of the definitive host; b — anterior and posterior end of fourth-stage larva (female) 9 days after infection of the definitive host (after Supryaga, 1967a).

The larvae later migrate through the air sacs into the subcutaneous tissue, where the fourth molt and copulation take place after 12 days in males and after 13–14 days in females.

After copulation, the vulva, vagina, and anus of females become obliterated; the intestine atrophies and is pressed against the body wall by the strongly developed uterus, which is filled at first with eggs and then with larvae; four weeks after infection of the definitive host, *A. mosgovoyi* begins to discharge larvae. Under optimal conditions the entire life cycle in the intermediate and definitive hosts lasts 36 – 53 days.

Supryaga (1969b) established experimentally that the males of *A. mosgovoyi* remain viable for a long time and actively emerge from the tissues of the bird 2–3 days after the death of the host; the life of males in the definitive host lasts markedly longer than of females, as long as 260 days. The author assumed that repeated fertilization of females during a second infection may occur, even if a second infection takes place after a long time.

Avioserpensiasis of aquatic birds (after Supryaga, 1967a, 1969a). *Avioserpens mosgovoyi* causes a disease which is widely distributed in the flooded Azov limans in the Krasnodar Territory, infecting to 35% of coots and to 20–25% of grebes.

Mature females are localized mainly in the subcutaneous tissue of the submaxillary space, forming large tumors. The size and weight of the head of the bird are often doubled by the tumors.

At a high intensity of infection (more than 15 specimens), mature females of *Avioserpens* also become localized in the subcutaneous tissue of the head, neck, trunk, legs and wings and in the serosa of the intestine and around the cloaca. In places where tumors are formed the skin becomes very thin and without feathers; the bulging parasite is distinctly visible through the skin.

In any localization, the cephalic end of females reaches an area of skin without feathers and the most frequent contact with water, i. e., the submaxillary region, around the eyes, the articulation of the wings, the knees and calcanean joints, the cloaca. The surface of the skin where perforations are made develops ulcers, each caused by a female. The ulcers increase in size and the area becomes covered with sores, which then dry and form scabs. The tumors are hard to the touch. The skin around them and subcutaneous fat are inflamed; The inflammation sometimes spreads, causing death of the bird. The helminths are situated under the skin in a thin serous capsule in a dense coil. The nematodes constantly contract, and when the tumors are large and the skin is markedly stretched, the movements frequently become visible through the skin while the bird is still alive. If the females are localized in the serosa of the large intestine and in other places, smaller masses are formed and it is easier to remove them.

When infected areas are opened, after a female has died and all larvae are discharged, a mass of necrotic tissue and nematodes are found. This entire mass is enclosed in the capsule; it is reddish brown and of loose consistency.

The most favorable conditions for the spread of the infection are present in stagnant water bodies, which dry up and contain large concentrations of *Cyclops* and *Diaptomus* (the intermediate hosts of *A. mosgovoyi*) and also fish, amphibians, and dragonfly larvae (reservoirs), which the birds eat. This is probably the reason that the highest rate of infection (to 35%) and intensity (more than 10 females) is found in such water bodies from July to September. The mortality of coots and grebes caused by *Avioserpens* is also highest in such water bodies.

279 *Avioserpensiasis* is a highly pathogenic disease. It is particularly severe in birds infected with 5 – 10 or more females of *A. mosgovoyi*; the birds lose weight (40–60%), become lethargic, and often die.

Supryaga stated that control is possible only by protecting water bodies against the entry of first-stage larvae. He suggests that at the beginning of June, when tumors are formed but the larvae have not yet been discharged, the birds should be shot.

References: Supryaga, 1965a, pp. 272–275; 1965b, pp. 275–277; 1967a, pp. 199–202; 1967b, pp. 243–244; 1969a, pp. 65–67; 1969b, pp. 45–246.



FIGURE 156. *Avioserpens mosgovoyi* Suprjaga, 1965:

a — tumor in the submaxillary region of a coot, caused by *A. mosgovoyi*; b — *A. mosgovoyi* under the skin of the submaxillary region of *Podiceps cristatus*; c — *A. mosgovoyi* under the skin in the femoral region of *Fulica atra* (after Supryaga, 1967).

SUBFAMILY *MICROPLEURINAE* BAYLIS AND
DAUBNEY, 1922

Diagnosis. Dracunculidae. Mouth rounded, with 4 (double?) papillae in the outer ring. Esophagus divided into a muscular and a glandular part or not divided. Males with pointed tail; caudal wings absent, or only a right wing present. Caudal papillae present. Spicules developed.

Vulva situated at the anterior end or in middle of body.

Type genus: *Micropleura* Linstow, 1906.

Genus *Micropleura* Linstow, 1906

Diagnosis. Micropleurinae. Cuticle with fine transverse striation and irregular rows of small tubercles. Esophagus divided into a short anterior and a long, wide posterior part.

Male. Caudal wings present. End of tail conical, pointed. Three pairs of preanal and 4 pairs of postanal papillae. Spicules, short, very thin and pointed. Gubernaculum well developed.

Female. Tail bluntly rounded. A pair of large, protruding subventral papillae. Vulva indistinct, situated slightly before middle of body. Vagina and vulva without musculature. Viviparous.

Parasites of the body cavity and serosa of reptiles.

Type species: *Micropleura vivipara* Linstow, 1906.

Micropleura vivipara Linstow, 1906 (Figure 157)

Host: *Gavialis gangeticus*.

Localization: body cavity, serosa.

Distribution: Zoological Garden in Calcutta.

Description (after Linstow, 1906c). Cephalic end without teeth or lips; anterior end rounded, with 6 papillae arranged in a ring and only 280 slightly protruding; mouth small and round; cuticle smooth; lateral lines low and narrow, without a canal; excretory pore absent; end of tail rounded.

Male. Length 35 mm, width 0.72 mm. A thickening on each side which ends in a papilla. Musculature strongly developed; lateral lines 0.03 mm wide, wider laterally. Length of esophagus 4.009 mm. Nerve ring situated 1.002 mm from the cephalic end. Tail 0.062 mm long. On each side of the tail are three small papillae arranged in an arc on the ventral side; then follows a postanal papilla on a circular elevation on each side and behind them a small papilla on one side of the short tail. Both spicules 0.47 mm long.

Female. Length 37 mm, width 0.79 mm. Length of esophagus 5 mm. Nerve ring situated 1.25 mm from the cephalic end. Vulva situated slightly before middle of body, dividing the body at the ratio of 5:6. The branches of the uterus pass into the ovaries anteriorly and posteriorly. Ovaries 2.31 mm long. Tail 0.207 mm long. Viviparous.

Larvae in the uterus 0.57 mm long, 0.017 mm wide. Cephalic end rounded. Tail long, pointed. Cuticle with distinct transverse striation.

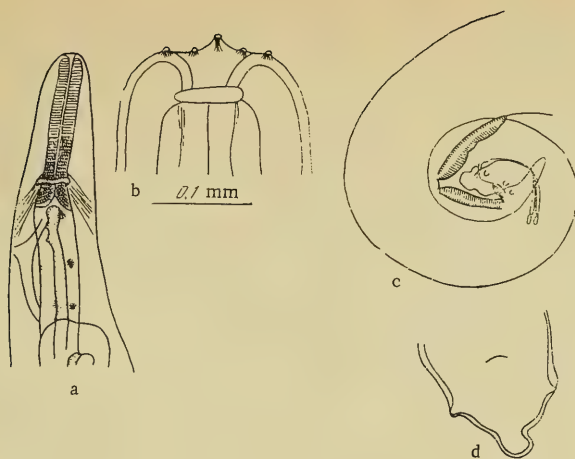


FIGURE 157. *Micropleura vivipara* Linstow, 1906:

a — anterior end; b — cephalic end; c — caudal end of male, lateral; d — caudal end of female, ventral (a, d — after Baylis and Daubney, 1922; b — after Baylis, 1939; c — after Baylis, 1924).

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 86; Linstow, 1906c, pp. 269–270; Yamaguti, 1961b, p. 194; Yorke and Mapleston, 1926, p. 436.

281 *Micropleura indica* Khera, 1951 (Figures 158, 159)

Hosts: definitive — *Trionyx gangeticus*, *Lissemys punctata*; intermediate — *Cyclops*.

Localization: body cavity.

Distribution: India.

Description (after Khera, 1951). Medium-sized nematodes. Cuticle thin, delicate. Mouth surrounded by 6 papillae, two lateral, two subdorsal, and two subventral.

Male. Length 5–7 mm, width 0.41 mm. Width at the cephalic papillae 0.09 mm. Cuticular striation very fine. Length of esophagus 1.08–1.55 mm. Esophagus divided into a muscular anterior part 0.26–0.4 mm long and a glandular posterior part. Tail pointed, 0.245 mm long. Five pairs of postanal and 3 pairs of preanal papillae; all papillae pedunculate. Postanal papillae slightly smaller than the preanal papillae. Left spicule 0.172–0.2 mm long, right spicule 0.14–0.16 mm. Gubernaculum strongly chitinized, 0.052 mm long.

Female. Body blunt at both ends. Length 16–23 mm, width 0.84 mm. Width of head at the cephalic papillae 0.19 mm. Cuticle smooth, but with 2–6 rows of small papillae which protrude markedly in the region of the esophagus and project less in the posterior part of the body. Length of esophagus 1.9–2.02 mm, length of muscular anterior part 0.585 mm.

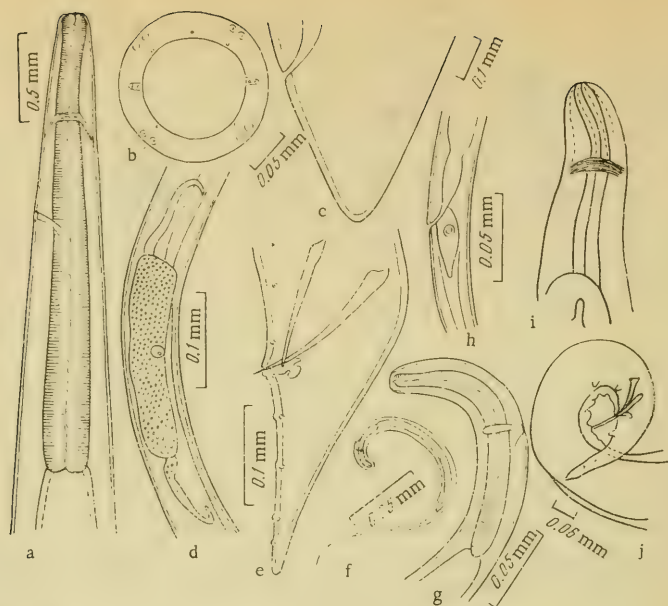


FIGURE 158. *Micropleura indica* Khera, 1951:

a — anterior end of female, lateral; b — cephalic end of female, apical; c — tail of female, lateral; d — female genitalia; e — caudal end of male, lateral; f — first-stage larva; g — anterior end of first-stage larva, lateral; h — anal region of first-stage larva, lateral; i — anterior end; j — caudal end of male, lateral (a—h — after Siddiqi and Jairajpuri, 1963; i, j — after Khera, 1951).

Nerve ring situated 0.501 mm, excretory pore 0.9–1.02 mm from the cephalic end. Tail 0.28 mm long. Vulva situated before middle of body, 3.1 mm from the cephalic end in a young female 7.2 mm long. Vulva atrophied in adult females. Vagina narrow, without musculature. Branches of uterus opposite. Eggs $0.05\text{--}0.080 \times 0.040$ mm large. Length of larvae 0.72–0.87 mm, width 0.020 mm. Length of esophagus 0.17 mm. Length of tail 0.39 mm.

Description (after Siddiqi and Jairajpuri, 1963). Body compact, slightly narrowing toward the rounded cephalic end and the conical caudal end. Cuticle thin and transparent, without striation or small papillae. Mouth terminal, without cuticularization, surrounded by a double ring of papillae. Six large papillae in the outer ring and 6 papillae in the inner ring. Amphids large, protruding, opening in pores which are situated laterally. Esophagus divided into a muscular anterior part and a glandular posterior part. Nerve ring situated at the connection between the two parts. Protruding muscles absent at the level of the nerve ring. Longitudinal nerve fibers well developed.

Male. Length 4.54–6.12 mm, width 0.27–0.36 mm. Length of esophagus 0.90–1.14 mm, length of the short muscular part 0.18–0.23 mm; ratio of length of muscular and glandular parts 1:4. Tail conical, tapering,

0.19–0.22 mm long; 3 pairs of preanal and 5 pairs of postanal papillae. Smaller spicule 0.11–0.14 mm long, larger spicule 0.12–0.17 mm. Gubernaculum strongly projecting.

Female. Length 25.0 mm, width 0.87 mm. Length of muscular anterior part of esophagus 0.68 mm, of glandular posterior part 2.12 mm; this part slightly wider than the anterior part. Ratio of length of the two parts about 1:3. Uterus didelphic, amphidelphic, large, with twisted ovaries. Vagina small, narrow. Vulva not functional, atrophied, situated in about middle of body. In mature females the uterus contains numerous first-stage larvae and fills the entire body cavity.

Life cycle (after Siddiqi and Jairajpuri, 1963). The larvae of *M. indica* are of typical dracunculid structure. The larvae are discharged into the water. When larvae are kept together with *Cyclops*, these become infected in 2 hours.

The larvae molt twice in the *Cyclops* and develop into third-stage larvae after about 6 days.

First-stage larvae thin, very active, free-swimming; when swallowed by *Cyclops*, they enter the body cavity through the intestine after 8–12 hours. The larvae remain active in the intestine and also in the body cavity, where they feed on the fluid. Infected *Cyclops* usually contain 4–6 larvae, sometimes to 14. Length of larvae 0.86–0.89 mm, width 0.025–0.026 mm. Cuticle thin and delicately striated. Length of esophagus 0.16–0.17 mm. Nerve ring situated 0.068–0.089 mm, 283 excretory pore 0.075–0.090 mm from the cephalic end. Phasmids large, protruding, saclike, situated slightly behind the anus. Tail 0.35–0.38 mm long, threadlike, with pointed end.

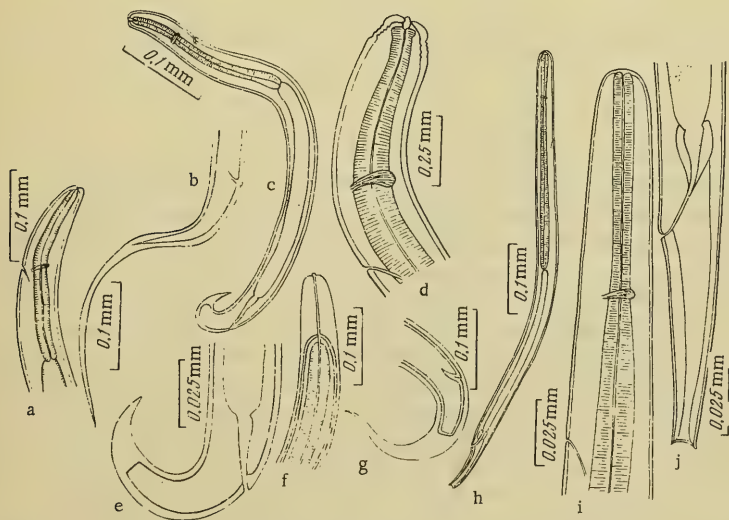


FIGURE 159. *Micropleura indica* Khera, 1951:

a — anterior end of first-stage larva at the molt; b — posterior end of first-stage larva at the molt; c — second-stage larva; d — anterior end of second-stage larva; e — posterior end of second-stage larva; f — anterior end of second-stage larva at the molt; g — posterior end of second-stage larva at the molt; h — third-stage larva; i — anterior end of third-stage larva; j — posterior end of third-stage larva (after Siddiqi and Jairajpuri, 1963).

Second-stage larva. First-stage larvae molt 36–48 hours after they have been swallowed by *Cyclops*. The second-stage larvae remain about 12–24 hours in the body cavity of the host. They are 0.52–0.6 mm long and 0.027–0.032 mm wide. Intestinal tract divided into an esophagus 0.18–0.19 mm long, an intestine 0.25–0.26 mm long, and a rectum 0.025–0.032 mm long. Esophagus not yet divided into a muscular and a glandular part. Nerve ring situated 0.057–0.064 mm, excretory pore 0.079–0.081 mm from the cephalic end. Tail short, pointed, 0.074–0.095 mm long.

Third-stage larva. The second-stage larvae shrink and remain inside the sheath until the internal organs become differentiated; this takes place after 40–50 hours. The host is exhausted and sluggish at this time. Some *Cyclops* infected with numerous larvae die; they decompose, and the larvae pass into the water, remain active for some time and then die. Third-stage larvae resemble the second-stage larvae in size and general appearance, differing only in a few details. Length 0.53–0.71 mm, width 0.025–0.038 mm. Length of esophagus 0.18–0.32 mm; length of muscular 284 anterior part 0.062–0.10 mm, of glandular posterior part 0.12–0.22 mm. Intestine 0.22–0.29 mm long; rectum 0.32–0.043 mm long. Nerve ring situated at the connection between muscular and glandular part of esophagus. Excretory pore situated 0.085–0.14 mm from the cephalic end. Tail blunt, 0.043–0.072 mm long.

Infection of *Lissemys punctata* was not performed.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 86; Khera, 1951, pp. 55–58; Siddiqi and Jairajpuri, 1963, pp. 99–105; Yamaguti, 1961b, p. 195.

Micropleura vazi Travassos, 1933

Host: *Caiman sclerops*.

Localization: abdominal cavity.

Distribution: South America.

Description (after Travassos, 1933). Cuticle smooth, with longitudinal rows of cones and with transverse striation on the whole body with intervals of 0.040–0.064 mm. Musculature polmyarian, with narrow lateral fields. Sexual dimorphism marked. Mouth simple, apparently with two primitive lips and with three pairs of markedly reduced papillae. Excretory pore situated at the middle of the esophagus, consisting of a large cell with 4 processes, two anterior and two posterior, which are situated obliquely to the lateral fields. Esophagus divided into a muscular and a glandular part. Each consists of two almost equal parts. Nerve ring situated at the connection between anterior and posterior part of esophagus.

Male. Length 6 mm, width 0.7 mm. Length of esophagus 1.2 mm, length of thinner anterior part 0.33 mm, of posterior part 0.93 mm. Excretory pore situated 0.28 mm from the cephalic end. Tail coiled into a spiral, with lateral wings supported by 7 pairs of papillae; four more or less equally spaced postanal pairs and three preanal pairs, also equally spaced.

A single papilla before the cloaca. Two rows of cuticular cones on the ventral side. Spicules thin, threadlike, both about 0.168 mm long. Gubernaculum wedge-shaped, about 0.056 mm long. Cloaca situated 0.29 mm from end of tail. Genitalia consisting of an ejaculatory duct about 0.73 mm long and an almost straight vas deferens which ends before the end of the intestine.

Female. Length 25 mm, width 1 mm. Length of esophagus 2.2 mm, length of anterior part 0.60 mm, of posterior part 1.6 mm. Excretory pore situated 0.9 mm from the cephalic end. Tail conical, anus situated 0.5 mm from end of tail; vulva point-shaped, situated in middle of body. Ovejector reduced, atrophied in gravid females. The uterus consists of a large funnel-shaped sac which extends to the middle of the oviduct without forming loops. Oviducts and ovaries short. Ovaries situated at the ends of the body (amphidelphic), ending in a large, light-refracting cell. The uterus contains larvae at all stages of development, without eggs. Fully developed larvae tapering posteriorly; length about 0.37 mm, maximum width 0.013 mm. The esophagus is constricted and already divided into an anterior part about 0.11 mm long and a posterior part about 0.13 mm long. Anus situated 0.10–0.14 mm from the end of the awl-shaped tail. In the middle of the esophagus, 0.067 mm from the cephalic end, there is a short transverse ridge which is of light color and does not stain, probably the primordium of the excretory cell. The larvae pass out through ruptures of the uterus and the body wall.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 90; Travassos, 1933, pp. 161–163; Yamaguti, 1961b, p. 195.

Micropleura trionyx Agrawal, 1966 (Figure 160)

Host: *Trionyx gangeticus*.

Localization: intestine.

Description (after Agrawal, 1966a). Medium-sized nematodes; body tapering at both ends. Cuticle thin, delicately striated. Cephalic end with 6 papillae, two lateral and 4 submedian. Esophagus divided into a short, narrow, muscular anterior part and a longer, wider, glandular posterior part.

Male. Length 3.5–3.76 mm, width 0.18–0.26 mm; width of cephalic end 0.05–0.08 mm. Buccal capsule very short. Length of muscular part of esophagus 0.15–0.25 mm, width 0.04–0.06 mm; length of glandular part 0.65–0.98 mm, width 0.06–0.08 mm; length of esophagus 0.80–1.13 mm. Nerve ring situated 0.16–0.23 mm, excretory pore 0.67–0.74 mm from the cephalic end. Eight pairs of caudal papillae: four pairs preanal, one pair adanal, three pairs postanal; a pair of phasmids at the end of the tail. Both spicules tubular, 0.14–0.18 mm long; gubernaculum long, wedge-shaped, 0.04 mm long.

Female. Length 4.62–6.92 mm, width 0.53–0.71 mm; width of cephalic end 0.05–0.07 mm. Length of muscular part of esophagus 0.21–0.31 mm, width 0.06–0.08 mm; length of glandular part 0.95–0.25 mm, width 0.09–0.10 mm. Nerve ring situated 0.19–0.28 mm, excretory pore

0.53—0.56 mm from the cephalic end. Tail conical, 0.10—0.15 mm long. Vulva situated nearly in middle of body, 2.72—3.66 mm from the cephalic end. Viviparous.

(285)

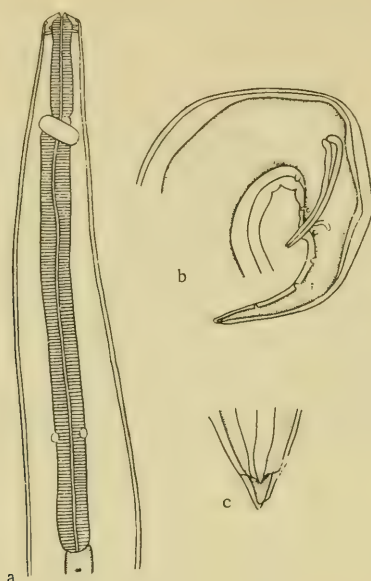


FIGURE 160. *Micropleura trionyx* Agrawal, 1966:

a — anterior end of male, lateral; b — caudal end of male, lateral; c — caudal end of female, ventral (after Agrawal, 1966a).

Reference: Agrawal, 1966a, pp.107—114.

FAMILY *PHILOMETRIDAE* BAYLIS AND DAUBNEY, 1926

Diagnosis. Dracunculoidea. Length varying. Cephalic end rounded. Mouth simple, without lips, surrounded by 6 or 8 papillae. Anus sometimes absent in adults.

Male much smaller than female; spicules of the same length, thin, pointed; gubernaculum present or absent.

Female. Vulva indistinct or absent. Vagina rudimentary or absent in females filled with larvae. Branches of uterus opposite, tubular. Ovaries short, situated at ends of body. Viviparous.

Parasites of the body cavity, serosa, and connective tissue of fish.

Type subfamily: Philometrinae Yamaguti, 1935.

Key to the subfamilies of the family Philometridae

- Esophagus divided into a muscular anterior part with two swellings and a short posterior part with a glandular appendage projecting into the intestine. Esophageal glands mononuclear
..... Philometrinae Yamaguti, 1935.
Esophagus divided into a narrow muscular anterior part and a widened glandular posterior part. Esophageal glands polynuclear
..... Philoneminae n. subfam .

SUBFAMILY *PHILOMETRINAE* YAMAGUTI, 1935

Historical review

Yamaguti (1935) established the subfamily Philometrinae Yamaguti, 1935, with five genera: *Philometra* Costa, 1845; *Philometroides* Yamaguti, 1935; *Clavinema* Yamaguti, 1935; *Ichthyofilaria* Yamaguti, 1935; *Sanguinofilaria* Yamaguti, 1935.

Skrjabin et al. (1954) added the genera *Philonema* Kuitunen-Ekbaum, 1933; *Coregonema* Bauer, 1946; *Phlyctainophora* Steiner, 1921, but only provisionally, since the subfamily was in need of revision; the authors stated that the genera described by Yamaguti in 1935 (*Philometroides*, *Clavinema*, *Ichthyofilaria*, and *Sanguinofilaria*) are known only from females.

Rasheed (1963) studied the species of the family Philometridae from a large material and recognized eight genera and three subgenera in the

genus *Philometra*: *Philometra*, *Alinema*, and *Ranjhinema*. Two of these genera have been established recently: *Nilonema* Khalil, 1960 and *Rumai Travassos*, 1960, and two were established by the author, 287 *Buckleyella* Rasheed, 1963 and *Thwaitia* Rasheed, 1963. Rasheed retained *Philometra* Costa, 1845, *Ichthyofilaria* Yamaguti, 1935, *Philonema* Kuitunen-Ekbaum, 1933, and *Philometroides* Yamaguti, 1935, but she considered *Clavinema* Yamaguti, 1935 as a synonym of *Philometra* and does not discuss the genus *Coregonema*, since she considered some of its characters as doubtful; she does not mention the genus *Phlyctainophora*.

After a detailed study of the cephalic ends and the cuticle of the species of *Philometridae* and the discovery of cephalic papillae and cuticular processes of varying form and structure, Rasheed (1963) redistributed the species in the genera of the family; we have accepted her classification.

Diagnosis. *Philometridae*. Esophagus short, entirely muscular or divided into a short muscular anterior part and a relatively long glandular posterior part. Anus and vulva atrophied. Body long and threadlike (the females are markedly longer than the males in this case) or relatively short and thick. Viviparous.

Type genus: *Philometra* Costa, 1845.

Key to the genera of the subfamily *Philometrinae* (after Rasheed, 1963)

- Cuticle smooth 1.
- Cuticle with processes 5.
- 1. Muscular anterior part of esophagus elongate, with two swellings separated by the nerve ring, with a free posterior glandular process at the connection of the two parts *Ichthyofilaria* Yamaguti, 1935 .
- Esophagus without the above characters 2.
- 2. Four large, lobe-shaped cephalic papillae 3.
- More than four cephalic papillae, papillae indistinct, small or large 4.
- 3. Esophagus swollen or widened near the mouth. Tail of female blunt or rounded *Thwaitia* Rasheed, 1963 .
- Esophagus not swollen around the mouth, cylindrical. Tail of female conical *Rumai Travassos*, 1960 .
- 4. Tail of female blunt, rounded, or slightly tapering. Tail of male blunt or rounded, with or without lobes; cloaca terminal *Philometra* Costa, 1845 .
- 5. Cuticle with cone-shaped processes; esophagus cylindrical, not widened around the mouth. Tail of female pointed ... *Nilonema* Khalil, 1960 .
- Cuticle without cones; esophagus bulb-shaped or slightly widened around the mouth. Tail of female rounded or blunt 6.
- 6. Cuticle with finger-shaped cuticularized structures arranged in a certain order; cephalic papillae forming large, flattened lobes. Cuticularized teeth present in the esophagus ... *Buckleyella* Rasheed, 1963 .
- Cuticle with small, irregularly arranged cones; cephalic papillae small. Teeth absent in esophagus *Philometroides* Yamaguti, 1935 .

Key to the subgenera of the genus *Philometra*

1. Cephalic papillae of outer ring large, lobe-shaped, arranged in double pairs *Ranjhinema* Rasheed, 1963.
Cephalic papillae of outer ring smaller, sometimes fused but not arranged in double pairs as in *Ranjhinema* 2.
2. Slit of mouth covered with small structures appearing like beads; cephalic papillae small, difficult to see *Alinema* Rasheed, 1963.
Slit of mouth simple, without ornamentation; cephalic papillae of both rings distinct *Philometra* Rasheed, 1963.

288 Genus *Philometra* Costa, 1845

Synonyms: *Filaria* Mueller, 1787 (in part); *Ichthyonema* Diesing, 1861; *Sanguinofilaria* Yamaguti, 1941

Historical review

Philometra reticulatum Costa, 1845 was described from *Uranoscopus scaber*. Railliet (1916) compared the species with *Filaria globiceps* Rudolphi, 1819, which had been transferred by Diesing (1861) to the genus *Ichthyonema*, and considered them identical and the names *Filaria* and *Ichthyonema* as synonyms of the genus *Philometra* with the type species *Ph. globiceps*, making *Ph. reticulatum* a synonym. The number of species in this genus is rapidly increasing, but the validity of many species is doubtful. Skrjabin et al. (1954) list 37 species in the genus, Yamaguti (1961) 44 species, and Rasheed (1963), who revised the genus, about 50 species.

Diagnosis. *Philometrinae*. Body cylindrical, with blunt, rounded, or slightly tapering ends. Cuticle smooth. Cephalic papillae present: outer papillae arranged in pairs, fused or double; inner circle, if present, consisting of 4 submedian papillae. Esophagus with an anterior widening, with an esophageal gland and a ventricle or without them. Intestine ending blind. Anus and vulva absent. Ovaries opposite, uterus compact. Viviparous. Males with spicules of the same or of nearly the same length. Gubernaculum present or absent. Cloaca terminal. Parasites of marine and freshwater fishes.

Type species: *Philometra globiceps* (Rudolphi, 1819) Railliet, 1916.

Subgenus *Philometra* Rasheed, 1963

Philometra globiceps (Rudolphi, 1819) Railliet, 1916
(Figures 161–163)

Synonyms: *Filaria globiceps* Rudolphi, 1819; *Philometra reticaudata* Costa, 1845

Hosts: *Blennius phycis*, *Uranoscopus scaber*.

Localization: body cavity, gonads.

Distribution: Mediterranean, Bermuda, Black Sea.

Description (after Willemoes-Suhm, 1871). Live nematodes blood-red, with dark intestine, which extends close to the body wall almost to the posterior end. Musculo-cutaneous sac 0.014 mm thick. Anterior end of esophagus slightly widened, mouth funnel-shaped, without lips, with 4 papillae. Esophagus very short, consisting of radial muscle fibers with a structureless membrane outside and lined with the continuation of the cuticle. Esophagus rounded posteriorly, intestine much wider, with thin walls, wide lumen, ending blind before the posterior end, attached to the caudal muscles only by thin strands. Tail short, rounded. Anus not found.

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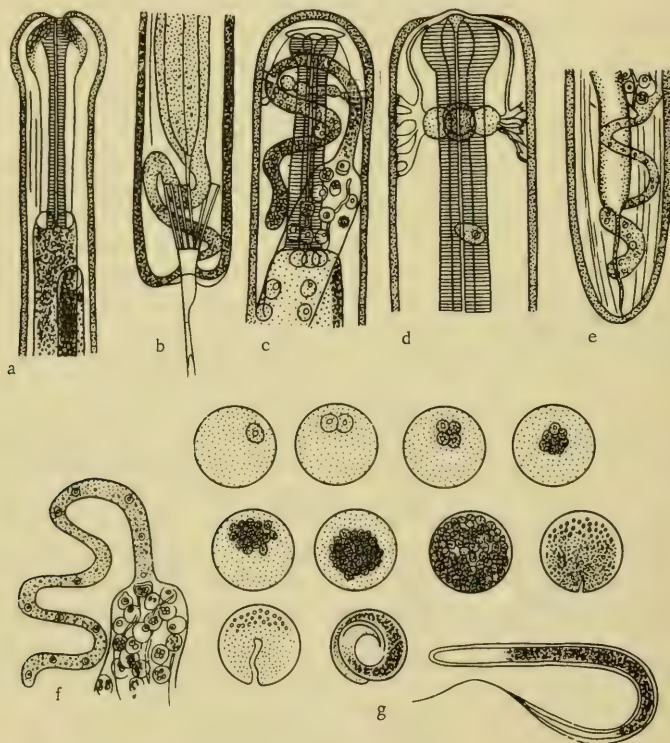


FIGURE 161. *Philometra globiceps* (Rudolphi, 1819):

a — anterior end of male; b — posterior end of male; c, d — anterior end of female; e — posterior end of female; f — beginning of uterus; g — development of eggs and first-stage larva (after Willemoes-Suhm, 1871).

Male. Length 6 mm, width 0.1–0.29 mm. Genitalia represented by testes and vas deferens. One spicule, with bifid end.

Female. Length 200 mm, width 1–2 mm. Two ovaries and a duct connecting them which functions as a uterus. One ovary situated at the cephalic and the other at the posterior end, the first forming loops around the esophagus and the second around the intestine. The uterus of mature females is filled with larvae with a long, thin tail which tapers to a point. Length of larvae 0.56 mm, width 0.02 mm. Mouth absent, but at the anterior end is a very narrow tube followed by a granulate primordium of the intestine. In the uterus of a female more than 20 mm long eggs at all stages of development may be present.

Description (after Linton, 1901). Blood-red nematodes, with dark brown intestine. Uterus filled with active larvae with some granulated speckles in the middle of the body.

Female. Length 55 mm, width uniform, 0.45–0.70 mm. Width of cephalic end 0.19 mm.

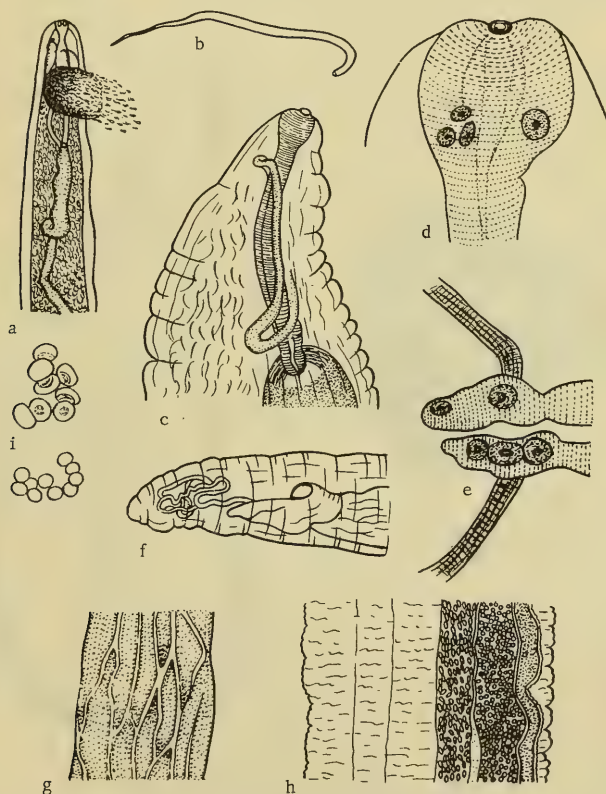


FIGURE 162. *Philometra globiceps* (Rudolphi, 1819):

a — anterior end of specimen from *Lobotes surinamensis*; b — larva from uterus; c — anterior end of specimen from *Pomatomus saltatrix*; d — beginning of intestinal tract; e — connection of esophagus and intestine; f — posterior end; g — part of wall of intestine at the posterior end, characteristic reticulation visible; h — longitudinal section of part in middle of body of specimen from *Tarfon atlanticus*; i — eggs (after Linton, 1901).

Description (after Kovaleva and Khromova, 1967). Large nematodes; mature specimens reddish brown, juveniles light yellow, body long, thread-like, of uniform width, except at the rounded ends, which are slightly narrower. Cuticle thin and smooth. Mouth simple. Cephalic end with 8 papillae, four in the outer ring and four in the inner ring; papillae distinct in apical view. Only the four papillae of one ring are visible in dorsal view, so that Willemoes-Suhm mentioned only four papillae. One pair of lateral amphids. Esophagus straight, muscular, widened anteriorly; it ends in a ventricle consisting of several large cells projecting into the intestine. Intestine wide, dark reddish brown. It becomes markedly narrower posteriorly and ends blind, adhering to the body wall near the posterior end. Nerve ring distinct. Uterus occupying nearly the whole body cavity, filled with larvae; it extends slightly anteriorly beyond the posterior end of the esophagus. Vulva and anus absent.

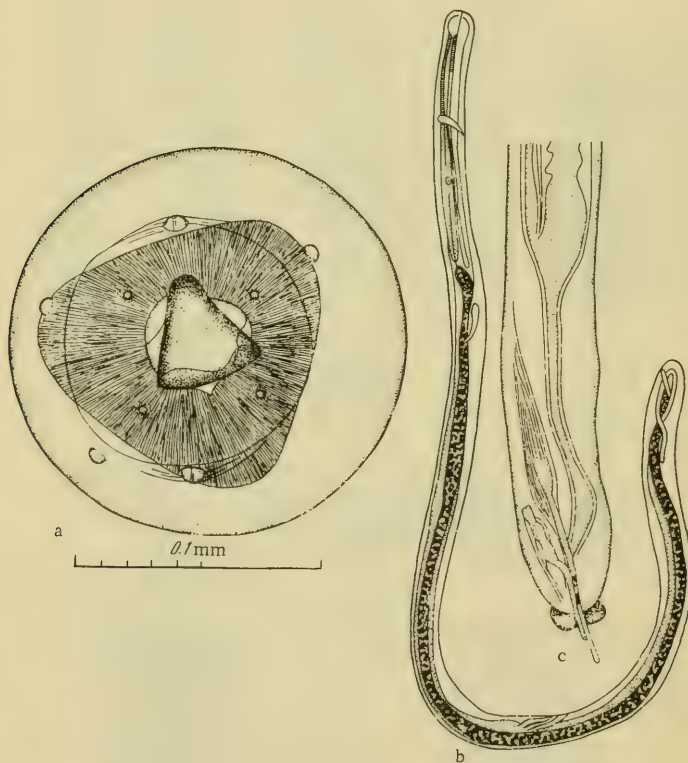


FIGURE 163. *Philometra globiceps* (Rudolphi, 1819):

a — cephalic end, apical; b — general view; c — posterior end of male (b, c — after Yorke and Maplestone, 1926).

Male. Length 1.67–4.6 mm. Measurements are of a male 4.6 mm long. Width 0.08 mm. Length of esophagus 0.32 mm, width 0.088 mm. Nerve ring situated 0.104 mm from the cephalic end. Spicules of the same length, needle-shaped, 0.137 mm long; gubernaculum 0.044 mm long.

Female. Length 23.017 to 60 mm. Measurements of specimens 60 mm long. Width 0.60 mm. Length of esophagus 0.9 mm, width 0.15 mm. Nerve ring surrounding esophagus 0.214 mm from the cephalic end.

292 Life cycle not studied. The literature mentions only a few failures to infect Cyclops and Decapoda with larvae of *Ph. globiceps*. Dissection of *Uranoscopus scaber* from the Black Sea (Kovaleva and Khromova (1967)) showed a high infection rate with this parasite (35.1–86.5%); the intensity of infection varied from 2 to 9 specimens. The fish became infected after spawning in summer-autumn; later development of the nematodes and of the genital products apparently takes place at the same time. When the fish begin to spawn, the larvae pass out of the body through a rupture in the body wall and are discharged together with the genital products of the fish into the water, where they live free for 8–9 days at 22–24°. The experiments of Kovaleva and Khromova to infect crustaceans with larvae of *Ph. globiceps* were negative. The life cycle of the parasite is completed in a year. Adults do not leave their localization in the host, and the dark, dried cuticle of nematodes of earlier infections are therefore often found during dissection.

References: Kovaleva and Khromova, 1967, pp. 472–473; Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 73; Linton, 1961, pp. 441–481; 1967, pp. 85–126; Willemoes-Suhm, 1871, pp. 175–203; Yamaguti, 1961b, p. 75.

Philometra abramidis Osmanov, 1964
(Figure 164)

Host: *Abramis brama*.

Localization: kidneys.

Distribution: USSR (Syr-Darya River).

Description (after Osmanov, 1964). Body threadlike. Mouth surrounded by papillae.



FIGURE 164. *Philometra abramidis* Osmanov, 1964.

Posterior end of male (after Osmanov, 1964).

Male. Length 2.00 mm, width 0.05 mm. Spicules of different length. Larger spicule 0.249 mm long, smaller spicule 0.156 mm. Gubernaculum present, 0.066 mm long. Cloaca situated at the posterior end, with two liplike processes.

Female unknown.

Reference: Osmanov, 1964, pp.38—42.

Philometra amazonica Travassos, 1960 (Figure 165)

Host: *Calophysus macropterus*.

Localization: body cavity.

Distribution: Amazon River.

Description (after Travassos, 1960).

Male unknown.

- 293 Female. Coloration pink, body cylindrical. Length 250—950 mm, width 0.50—1.0 mm. Cephalic end blunt, without formations. Posterior end conical, blunt. Cuticle smooth. Mouth triangular, passing directly into the esophagus. Esophagus club-shaped, with widened anterior end, forming a pseudobulb, and a narrower part where the nerve ring is situated. Posterior part of esophagus gradually widening. Length of esophagus 1.20—1.40 mm. Nerve ring situated in anterior quarter of esophagus. Intestine cylindrical, dark, rectum narrow, transparent. Anus subterminal. Genitalia amphidelphic. Anterior ovary situated near esophagus, posterior ovary at the posterior end. In mature females the uterus is filled with larvae and occupies the entire body cavity. Larvae 0.416—0.445 mm long, maximum width 0.014 mm. Vulva not recognizable.

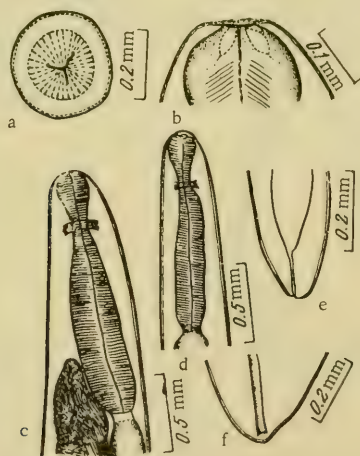


FIGURE 165. *Philometra amazonica* Travassos, 1960:

a — cephalic end, apical; b — same, lateral; c, d — anterior end, lateral;
e, f — posterior end (after Travassos, 1960).

Reference: Travassos, 1960, pp.15—20.

Philometra baylisi Vaz and Pereira, 1934
(Figure 166)

Host: *Pimelodus clarias*.

Localization: abdominal cavity.

Distribution: Brazil.

Description (after Vaz and Pereira, 1934). Cuticle transversely striated, without spines, papillae, or other formations. Mouth rounded, with 3 lips: two larger lateral lips and a smaller dorsal lip. The lips bear 3 small papillae, one of them median and two lateral. Esophagus beginning at the mouth; it is narrower at both ends and wider in the middle, 1.11 mm long.

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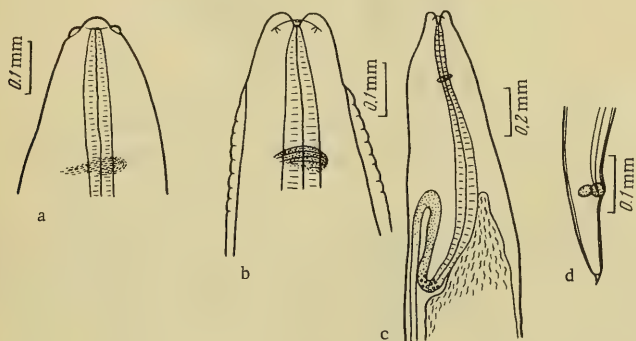


FIGURE 166. *Philometra baylisi* Vaz and Pereira, 1934:

a — anterior end, lateral; b — same, dorsolateral; c — same, showing esophagus and intestine; d — tail of female, lateral (after Vaz and Pereira, 1934).

Nerve ring situated 0.24 mm, excretory pore 0.51 mm from the cephalic end. Intestine atrophied, pressed against a side of the body by the uterus, forming a loop behind the esophagus. Vulva not recognizable. Anus situated 0.16 mm from posterior end. Tail ending in a spine 0.012 mm long.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 73; Vaz and Pereira, 1934, pp. 87—103; Yamaguti, 1961b, p. 76.

Philometra biglobocerca Belouss, 1965 (Figure 167)

Host: *Mugil soiuy*.

Localization: body cavity.

Distribution: USSR (Suifun River).

Description (after Belous, 1965).

Male unknown.



FIGURE 167. *Philometra biglobocerca* Belouss, 1965:

a — anterior end, lateral; b — posterior end, lateral (after Belous, 1965).

Female. Length 48 mm, width 1.2 mm. Cuticle with weak transverse striation. Posterior end slightly curved ventrally, with two spherical lateral processes 0.160 mm wide. Mouth surrounded by 6 papillae. Length of esophagus 1.24 mm, width 0.070 mm. Anterior end of esophagus with a club-shaped widening 0.100 mm wide. Intestine widest near the esophagus, then tapering posteriorly and ending blind. Ovaries threadlike, one extending from the anterior and one from the posterior end of the uterus. Uterus filled with larvae 0.350 mm long and 0.016 mm wide.

Reference: Belous, 1965, pp. 57–58.

Philometra fujimotoi Furuyama, 1932 (Figure 168)

Host: *Ophiocephalus argus*.

Localization: fins, body cavity.

Distribution: Japan.

Description (after Furuyama, 1934). Males markedly smaller than females. Male colorless. Live mature females from the fins of the host are pinkish red. Cuticle smooth, body threadlike. Mouth without lips or papillae. Esophagus cylindrical, short, consisting of muscular and glandular formations; esophageal gland with one large nucleus; intestine about half as long as the body, ending blind, rectum atrophied.

Male. Length 3.99 mm, width near posterior end 0.064 mm. Cephalic end rounded, without lips or papillae. Posterior end truncate, with a membranous process. Two spicules of the same length, needle-shaped, about 0.09 mm long, maximum width 0.007 mm.

Female. Length about 40 mm, maximum width 1.5–2.0 mm. Body tapering anteriorly and posteriorly, cephalic end rounded, posterior end pointed.

Esophagus cylindrical, about 2.5 mm long. Intestine forming a yellowish brown tube, almost half as long as the body.

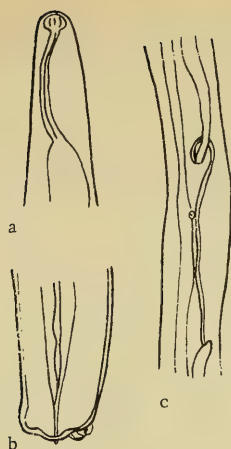


FIGURE 168. *Philometra fujimotoi* Furuyama, 1932:

a — anterior end; b — posterior end; c — region of vulva
(after Furuyama, 1934).

In mature females the uterus contains only fully developed embryos, occupying a large part of the body, from one end to the other, ending at both ends in an ovary which is turned in the opposite direction. Vulva and vagina not found in mature females but visible in the middle and posterior third of the body in young specimens.

Viviparous; uterus of mature females filled with larvae, younger females filled with eggs at different stages of development. The eggs are at first spherical and later ovoid, with thin, hyaline shell.

Larvae which have left the uterus are filarioid, 0.43 mm long and 0.015 mm wide, tapering posteriorly; tailthreadlike, a third as long as the body. Cuticle smooth, with fine transverse striation. Head rounded, mouth small, barely visible, without lips or papillae. The esophagus, in which a lumen is already visible, occupies the anterior third of the body. Intestine distinct because of the presence of granules which refract light strongly. Anus situated 0.09 mm from the posterior end.

The life cycle was studied in 1934 by Furuyama. Mature females burst when placed in tapwater. Thousands of larvae are released into the water and remain active for about a week. Their activity later decreases, and they die after 2 weeks.

Furuyama assumed that *Cyclops leuckarti*, *C. serrulatus*, *C. signatus*, *C. strenuus*, and *C. sp.* are intermediate hosts of *Ph. fujimotoi*. The larvae enter *Cyclops* and develop in the body cavity. Growth of the larvae apparently ceases after about a week, but the larvae remain alive for a long time in the host. Larvae 0.52–0.58 mm long, 0.013–0.015 mm wide.

Furuyama fed fully developed larvae from *Cyclops* to *Ophiocephalus argus*. Young adult females 11.5–13.5 mm long and 0.26–0.48 mm wide were found in the fins after 4 months. The female later grows larger without morphological changes. The rate of growth of the nematodes in the definitive host depends on the water temperature.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 74; Furuyama, 1932, p. 17; 1934, pp. 15-17; Yamaguti, 1961b, p. 76.

Philometra hyderabadensis Rasheed, 1963 (Figure 169)

Host: *Wallago attu*.

Localization: mesentery.

Distribution: India.

Description (after Rasheed, 1963).

Male unknown.

Female. Length 23 mm, width 0.03 mm. Body tapering slightly at both ends. Cuticle smooth, lateral fields distinct, with wide glandular areas.

Mouth simple, cephalic papillae typical for Philometridae. Papillae arranged in two rings: an outer ring with 8 papillae in pairs and an inner ring of 4 small submedian papillae. A pair of amphids situated laterally.

Esophagus beginning at the mouth, forming a bulb and with wide lumen anteriorly. It becomes narrower at the nerve ring, which is situated 0.19 mm from the cephalic end. Esophagus $1/7$ of the length of the body, 3.28 mm long and 0.85 mm wide at the anterior end. An esophageal gland with a large nucleus is situated in the middle, the excretory pore before it behind the nerve ring; the gland extends posteriorly to the end of the esophagus. A fleshy ventricle opens into the intestine, which ends blind before the end of the tail.

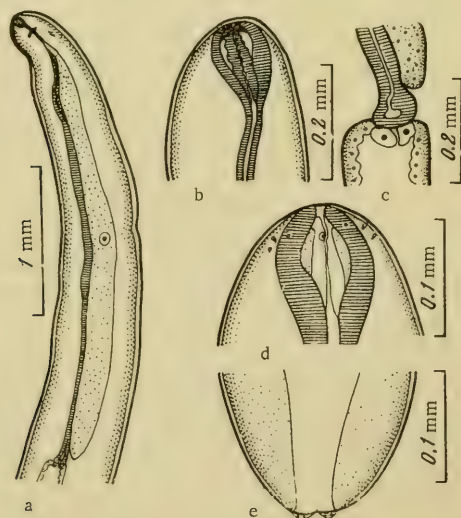


FIGURE 169. *Philometra hyderabadensis* Rasheed, 1963:

a — anterior end, lateral; b — cephalic end; c — posterior end of esophagus; d — cephalic end, papillae shown; e — posterior end of female (after Rasheed, 1963).

The thin anterior ovary begins near the posterior end of the esophagus; the posterior ovary begins at the end of the intestine. Uterus filled with larvae 0.18–0.25 mm long and 0.015–0.017 mm wide. Cephalic end of larva rounded and apparently with a toothlike process near the mouth. Tail distinctly tapering. End of tail rounded, slightly tapering, with two small papillae at the end, each with double nerve endings.

Reference: Rasheed, 1963, pp. 89–130.

Philometra inimici Yamaguti, 1941

Synonym: *Ph. cryptocentri* Yamaguti, 1961

Hosts: *Inimicus japonicus*, *Cryptocentrus filifer*.

Localization: outer surface of stomach, body cavity.

Distribution: Japan.

Description (after Yamaguti, 1941).

Male unknown.

Female. Length 140 mm, width 1.3 mm. Body pointed at the ends but of uniform width otherwise. Cephalic and caudal papillae absent. Cuticle thin, wrinkled. Nerve ring situated 0.24 mm from the cephalic end. Esophagus 1.06 mm long and 0.17 mm wide in the anterior part; an esophageal gland is present in about the middle. Ventricle indistinct, projecting into the intestine. Intestine dark, 0.5 mm wide at the beginning and tapering posteriorly, extending to the posterior end. Anterior ovary oval, 0.1 mm wide. Uterus extending to about the middle of the esophagus. Posterior ovary elliptical, 0.31 × 0.1 mm large, situated obliquely, behind the posterior end of the uterus, its distal end 0.35 mm before the posterior end; embryonal duct 0.15 mm long, widened at the connection with the uterus, which ends about 0.5 mm before the posterior end. Uterus long, cylindrical, with rounded ends, filled with embryos 0.31–0.36 mm long and 0.012–0.015 mm wide.

Description (after Yamaguti, 1961a, as *Ph. cryptocentri*).

Female. Length 93 mm, width 0.8 mm. Body threadlike, tapering at both ends. Cuticle thin and smooth. Cephalic end not pointed, without papillae. Esophagus 0.7 mm long, its anterior part widened, 0.078 mm wide, the other part cylindrical; ventricle about 0.050 × 0.080 mm, ending in valves. Intestine at first markedly widened, becoming thinner and obliterated posteriorly. The anterior ovary begins at the anterior end of the intestine, forms a double loop, and opens into the uterus 0.8 mm from the blunt posterior end, where it is curved before entering the uterus. Larvae 0.28–0.35 mm long and 0.010 mm wide.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 77; Yamaguti, 1941, p. 393; 1961a, p. 218.

Philometra lateobracis Yamaguti, 1935 (Figure 170)

Synonyms: *Sanguinifilaria lateolabracis* Yamaguti, 1935; *Philometra scomberomori* Yamaguti, 1935; *Ph. sciaenae* Yamaguti, 1935

Hosts: *Lateolabrax japonicus*, *Parapristipoma trilineatum*, *Epinephelus akaara*, *Sciaena schlegeli*, *Scomberomorus chinensis*, *Otolithus ruber*, *Hemisphamus georgii*, *Lates calcarifer*, *Johnius sina*.

Localization: ovary and oviduct.

Distribution: Japan, Pakistan, India.

Historical review

The species was designated as the type species of the genus *Sanguinifilaria*, in which the author also placed *S. pinnicola* Yamaguti, 1935 and *S. scomberomori* Yamaguti, 1935. He did not describe the genus very convincingly. He stated that it differs from *Philometra* in the absence of cephalic and caudal papillae and of a differentiated stomach (Yamaguti, 1935). Yamaguti (1941) transferred it later to *Philometra*, but considered the absence of cephalic and caudal papillae as the main characters. Rasheed (1963) studied the specimens in the British Museum and specimens from the ovary of *Otolithus ruber* on the coast of West Pakistan and stated that cephalic papillae are present in all specimens. Caudal papillae are absent. The glands of the ventricle are distinct. She also considered *Ph. scomberomori* and *Ph. sciaenae* as synonyms of this species. Rasheed (1965) recorded two new hosts of the species in West Pakistan.

Description (after Yamaguti, 1935). Body of uniform width its entire length, with rounded ends.

Male unknown.

Female. Length 23 mm, width 0.9 mm. Cuticle thin and smooth. Cephalic and caudal papillae absent. Mouth narrow, leading directly into the esophagus. Length of esophagus 1 mm, width 0.08–0.1 mm. The esophagus is divided into a slightly swollen muscular anterior part and a cylindrical posterior part which is connected with the esophageal gland on the dorsal side. The posterior end of the esophagus projects into the intestine with a small glandular appendage. Between the intestine and the esophagus is a rudimentary stomach consisting of a few cells which are compressed anteroposteriorly. Intestine wide, narrowing posteriorly into a thin canal which adheres to the body wall near its end. Intestine with dark brown contents. Nerve ring situated in the narrowest part of the esophagus, about 0.21 mm from the cephalic end. One cylindrical ovary at each end of the body; it turns toward the middle of the body after the beginning of each end of the uterus. Length of ovary 2.7–2.8 mm. Uterus filled with threadlike larvae which are 0.45 mm long and 0.018 mm wide. Vulva and vagina absent.

Description (after Yamaguti, 1941).

Male unknown.

Female. Length to 100 mm, width 0.55 mm. Body dark red, very wide, with bluntly pointed ends. Cephalic papillae absent or rudimentary. Caudal papillae absent. Nerve ring situated about 0.2 mm from the cephalic end. Esophagus to 1.06 mm long, 0.090 mm wide in the widened anterior part. Intestine to 0.42 mm wide at first, narrowing posteriorly; anus absent. Anterior ovary to 2.1 mm long, including the embryonal duct, which begins 2.65 mm from the cephalic end. Uterus extending almost to the cephalic end;

posterior ovary forming a loop at its posterior end. Larva with threadlike tail, length 0.47 mm, width 0.015 mm, genital opening situated at a point dividing the body at a ratio of 2.2–3.0:1.

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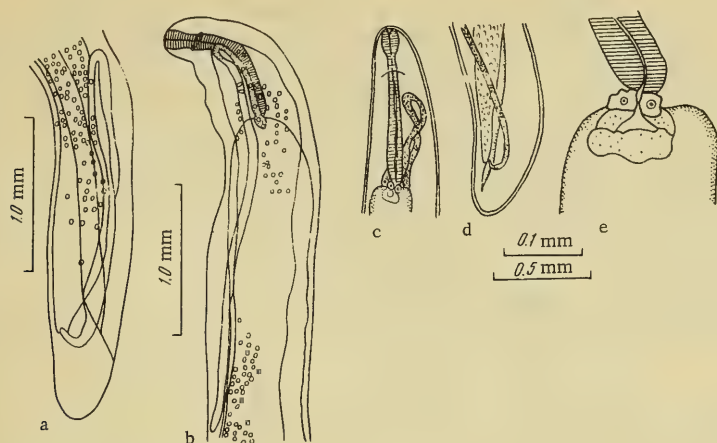


FIGURE 170. *Philometra lateobracis* Yamaguti, 1935:

a — posterior end, lateral; b — anterior end, lateral; c — same, showing esophagus; d — caudal end of female, lateral; e — transition of esophagus into intestine; glandular stomach and process visible (a, b — after Yamaguti, 1935; c–e — after Rasheed, 1963).

Description (after Rasheed, 1963).

Female. Length 130–200 mm, width 0.8–0.9 mm. Body of uniform width its entire length except at the bluntly pointed ends, which are slightly narrower. Cuticle thin and smooth. Cephalic papillae arranged in two rings: 4 papillae in the inner ring and 8 in the outer, the latter arranged in four pairs, the inner papilla of each pair situated submedially. There is also a pair of lateral amphids. All papillae are clearly visible in apical view. Esophagus widened at the cephalic end, entirely muscular, 0.9–1.4 mm long and 0.09–0.1 mm wide in the widest part, around the mouth. The ventricle and process contain distinct gland cells; they open into the intestine, which is very wide and occupies almost the entire width of the body. It ends blind near the posterior end and adheres to the body wall. Nerve ring surrounding esophagus 0.2–0.25 mm from the cephalic end. Ovaries thin. Uterus of mature females filled with larvae; eggs at different stages of development present in young forms. Length of larvae 0.47 mm, width 0.019 mm.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, pp. 78, 86; Rasheed, 1963, pp. 124–126; 1965, pp. 349–350; Yamaguti, 1935, pp. 358–360; 1941, p. 392; 1961b, p. 76.

Philometra managatuwo Yamaguti, 1941

Host: *Stromateoides argenteus*.

Localization: ovaries.

Distribution: Japan.

Description (after Yamaguti, 1941).

Male unknown.

Female. Length 460 mm, width 1.30 mm. Body dark red, with conical ends. Cephalic papillae absent or rudimentary. Caudal papillae absent. Nerve ring situated 0.2–0.25 mm from the cephalic end. Esophagus 0.85–1.075 mm long, 0.12–0.132 mm wide at the anterior swelling, with a glandular formation dorsally. Ventricle small, 0.13–0.35 mm. Intestine 0.5 mm wide at the beginning, reaching to the posterior end. Anterior ovary about 3.0 mm wide, beginning about 3.0 mm from the cephalic end; it crosses the esophagus where it turns posteriorly and passes into an embryonal duct 0.1 mm wide. Posterior ovary curved at the posterior end for about 1.5 mm. Uterus extending to the posterior end of the esophagus or slightly beyond it. Larvae 0.45–0.6 mm long and 0.015 mm wide.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 7; Yamaguti, 1941, p. 393; 1961b, p. 76.

301 *Philometra mariae* Layman, 1930 (Figure 171)

Hosts: *Protopsetta herzensteini*, *Limanda schrencki*, *Sebastodes schlegelii*.

Localization: subcutaneous tissue.

Distribution: USSR (Far East).

Description (after Lyaiman, 1930).

Male unknown.

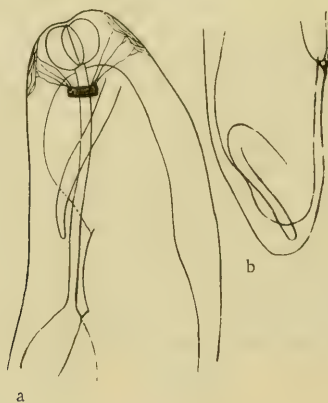


FIGURE 171. *Philometra mariae* Layman, 1930:

a — anterior end; b — caudal end (after Lyaiman, 1930).

Female. Length 1.6–3.2 mm, width 0.73–0.81 mm. Mouth surrounded by a characteristic buccal capsule 0.22 mm long and 0.24 mm wide. Esophagus 0.73 mm long. Intestine ending in a rudimentary anus. Uterus

with an anterior and a posterior branch. Nerve ring distinct, forming processes to the sides of the body. Genital opening absent. Viviparous.

References: Lyaiman, 1930, p.120; Yamaguti, 1961b, p.76.

Philometra ovata (Zeder, 1803) (Figure 172)

Synonym: *Filaria ovata* Zeder, 1803

Hosts: *Abramis brama*, *Rutilus rutilus*, *Leuciscus cephalus*, *Gobio fluviatilis*, *Rutilus caspicus*, *R. frisii*, *cutum*, *Abramis ballerus*, *Leuciscus leuciscus*, *L. idus*, *Vimba vimba*, *Aspius aspius*, *Blicca bjorkna*, *Phoxinus laevis*.

Localization: body cavity, occasionally intestine (females); males found on the serosa of the posterior sac of the swim bladder, rarely in the body cavity.

Distribution: Western Europe, USSR.

Description (after Skrjabin, 1923a).

Male. Length 6 mm, width 0.1 mm.

Female. Yellowish white, length 125 mm, width 1.5 mm. Larvae in uterus to 0.47 mm long and with a long tail (1/4 of length of body).

Description (after Kosareva, published for the first time).

Male not described.

Female. Length 9–9.3 mm, width 0.6–1.5 mm. Coloration yellowish white. Cephalic end rounded, with 4 weakly developed tubercles. Mouth triangular, bordered by three lobes in dorsal view. Buccal capsule absent. Esophagus slightly widened anteriorly, 1.5 to 2 mm long. Intestine ending blind. Uterus large, occupying entire body cavity, one ovary at each end. The size of the uterus changes with age. Vulva and vagina absent. Caudal end blunt, with distinct lateral tubercles which vary in size in different specimens. Viviparous.

Description (after Molnár, 1966a).

Male. Length 1.7–2.3 mm, width 0.045–0.053 mm. Transparent forms; cuticle smooth, with fine transverse striation. Cephalic end rounded, with 4 elongate papillae arranged around the periphery. Body almost uniformly wide its entire length, slightly narrowing at the cephalic end. Caudal end truncate, with two slightly projecting lateral teatlike processes which are connected by distinct narrow lobes. Two spicules of different length, with a short, thick stem and long, thin, tapering apical part. Larger spicule 0.246–0.325 mm long, smaller spicule 0.136–0.204 mm. Stem 0.007–0.009 mm wide, apical part at first 0.005 mm, average width 0.0025 mm. Gubernaculum 0.053–0.074 mm long, forming a curved chitinized plate with lanceolate apex. There is a hornlike process in its distal part, above which the gubernaculum is curved dorsally and anteriorly.

Males are localized in the peritoneum and on the serosa of the posterior sac of the swim bladder, rarely in the body cavity.

Female. Length 100–120 mm, width 0.8–1.2 mm. Mature females red, rarely yellowish red. Cuticle smooth. Cephalic end rounded, with 4 distinctly protruding papillae with wide base and with three lips. Esophagus and intestine pressed against the body wall. Posterior end with two distinct, flattened teatlike processes. Anus subterminal. Body cavity

303 occupied entirely by the uterus, which is filled with larvae. Length of larvae 0.4–0.5 mm. Young females yellowish red or red. Length 3.0–20.0 mm. Cuticle smooth, with fine vertical striation. Body cylindrical.

(302)

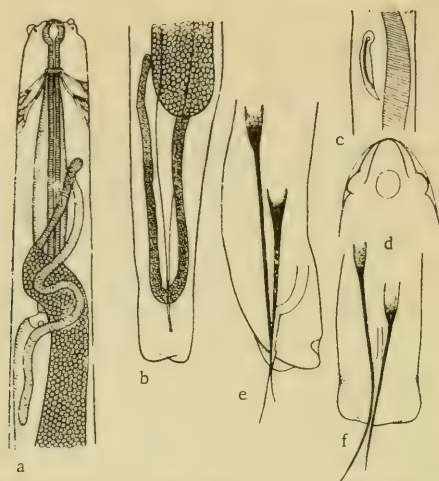


FIGURE 172. *Philometra ovata* (Zeder, 1803):

a — anterior end, lateral; b — posterior end; c — part of female;
d — cephalic end of male; e, f — caudal end of male, different as-
pects (after Molnár, 1966a).

Esophagus not divided and, except for the bulblike widening at the mouth, of uniform width its entire length. One side of the esophagus is serrated and bears an esophageal gland which opens into the esophagus below the anterior widening and continues until it is twice as wide as the esophagus in its middle. The esophagus is separated from the wider intestine by 3 valves. Intestine containing reddish brown pigment. Its width is uniform but it narrows markedly before the tail and continues to the subterminal anus.

Nerve ring situated below the esophageal bulb; distinct ganglia extend from it to the cuticle.

The tail ends in two large teatlike processes which project in small specimens. Vulva rounded, situated in the posterior third of the body; vagina with chitinized walls, extending anteriorly for 0.180–0.220 mm. Uterus filled with eggs, occupying the greater part of the body cavity. In young specimens the anterior end of the uterus gradually narrows and ends at the posterior end of the esophagus; in more mature females it is markedly curved and ends near the esophagus. From the anterior end of the uterus begins the long, cylindrical anterior ovary which forms one or two loops near the esophagus, then turns and ends behind the anterior end of the uterus. The posterior ovary extends to the posterior end of the uterus and forms several loops and ends abruptly. The two ovaries are connected with the uterus in the same manner.

Females move freely in the body cavity of bream and roach.

The life cycle of the species was studied by Molnár (1966a), who stated that in Lake Balaton mainly bream and roach older than one year infected with *Ligula* are severely infected with *Ph. ovata*. The rate of infection in both hosts is 100%. Infection with *Philometra* was not observed in fish less than a year old.

Molnár noted that females of *Ph. ovata* complete their life cycle only when the fish are also infected with *Ligula intestinalis* or *Diagramma interrupta*. This agrees with the data of Kreplin (1825), who found *Filaria cyprini rutilii* (probably identical with *Ph. ovata*) in a roach infected with *Ligula intestinalis*.

In breams not infected with *Ligula* and more than a year old the rate of infection is 100%; males and females of *Ph. ovata* are recorded throughout the year, but the intensity of infection is lower and only males become mature. The males are also localized in the wall of the swim bladder; there is thus no migration of females into the abdominal cavity. Such females never grow longer than 3 mm.

Infection of bream and roach in Lake Balaton takes place in the second half of June, and young males 0.96–1.01 mm long and 0.027–0.047 mm wide and young females 0.54–0.87 mm long and 0.016–0.045 mm wide were found at this time. There were also specimens from the abdominal cavity which were larvae with narrow tails. Specimens longer than 1 mm had already lost the long tail characteristic for the larvae and had rudiments of spicules or of a chitinized vaginal opening. The chitinized parts of the spicules of these specimens were never longer than 0.040 mm, and in males less than 1.4 mm long spicules were not found.

In July, growing males and females were found only in the swim bladder. Length of males 1.02–2.10 mm, width 0.032–0.061 mm, length of females 0.95–2.10 mm, width 0.032–0.059 mm.

In August, the males had grown to their full size. Their chitinized organs did not change further. Length of large spicule 0.246–0.325 mm, of small spicule 0.136–0.204 mm; length of gubernaculum 0.053–0.078 mm. After August females in fish containing plerocercoids and in fish without them developed differently.

In fish not infected with *Ligula* males are 1.70–2.20 mm long and 0.041–0.053 mm wide and females 1.66–2.36 mm long and 0.039–0.053 mm wide. They do not grow further and are localized in July under the serosa of the posterior part of the swim bladder. The chitinized part of the vagina of these females is 0.080–0.100 mm long.

In fish infected with plerocercoids the males also do not grow further but the females continue to grow and migrate from the air sac into the abdominal cavity. They are now 1.50–11.50 mm long and 0.029–0.034 mm wide. Developing eggs 0.004–0.006 mm wide are present in the uterus. Some females develop slowly and may continue to develop to the beginning of the next cycle under favorable conditions.

When the adult worms migrate, males and females may be found in the swim bladder, less frequently in the body cavity. After the females have left the host, the males disappear; at the end of July males and females of the same size which have not completed their growth may be found in the swim bladder.

In September, females which have migrated into the body cavity are 2.90–25.00 mm long; males which have remained in the swim bladder are

1.8–2.0 mm long. Together with the males there are often smaller females 1.4–5.6 mm long. Some of these probably migrate later.

According to the above data, copulation takes place in July or in early August. In March, the yellowishred or red females are actively moving in the body cavity of bream; they are 13.7–51.2 mm long and 0.36–0.68 mm wide. The uterus is filled with rounded, nonsegmented, thin-walled eggs 0.030–0.035 mm wide.

In April the color of females varies from bright red to dark red. They are 45–70 mm long, and the uterus contains eggs 0.035–0.040 mm wide with 8–32 blastomeres.

At the beginning of May the eggs become oblong, 0.040–0.052 mm large, with sickle-shaped embryos. The females are 70–90 mm long.

In the second half of May all females are 9–12 cm long. They are bright red. The uterus is filled with numerous free first-stage larvae.

At the end of May – early June fully grown females leave the host, enter the water, and burst; the larvae which are discharged settle on the bottom.

305 The free first-stage larva is 0.350–0.510 mm long and 0.012–0.022 mm wide in the middle. The cephalic end is rounded, the posterior end tapering.

Molnár found that some species of *Cyclops* common in Lake Balaton (*Cyclops strenuus*, *Macrocyclops albidus*, and *Acanthocyclops viridis*) swallow larvae in the water. The larvae of *Ph. ovata* pass through the wall of the intestine of the intermediate host and were observed mobile in the body cavity 15 days after infection. Death of the host stopped further development.

The life cycle of *Ph. ovata* is almost identical in roach.

References: Skrjabin, 1923a, pp.1–98; Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 76; Kreplin, 1825, p.86; Molnár, 1966a, pp.227–242; Nybelin, 1928, pp.1–4; 1931, pp.58–64; Yamaguti, 1961b, p.77.

Philometra parasiluri Yamaguti, 1935
(Figure 173)

Synonyms: *Ph. opsalichthydis* Yamaguti, 1935; *Clavinema parasiluri* Yamaguti, 1935

Hosts: *Opsalichthys uncistrostris*, *Parasilurus asotus*, *Mogurnda obscura*, *Zacco platypus*.

Localization: eye orbit, body cavity.

Distribution: USSR (Amur Basin), Japan.

Historical review

Yamaguti (1935) published a study of the helminth fauna of fish in which he described new species of *Philometra*, *Ph. parasiluri* and *Ph. opsalichthydis*. He also established the new genus *Clavinema* with the single species *C. parasiluri*, which is found in the same host as *Ph. parasiluri*. Rasheed (1963) stated that the only character distinguishing *Ph. parasiluri* and *Ph. opsalichthydis* is the

position of the esophageal gland and the granulate appearance of the esophagus in *Ph. opsalichthydis*; a granulate esophagus has not been found in other species of *Philometra*, possibly because the large granulate esophageal gland covers the entire esophagus. There is no great difference in the position of the opening of the esophageal gland: in one species it opens before the nerve ring, in the other below the nerve ring, which is probably a variation and not a specific character, and Rasheed therefore considered *Ph. opsalichthydis* as a synonym of *Ph. parasiluri*.

Rasheed also stated that the genus *Clavinema* Yamaguti, 1935 was described from unfertilized females. The generic diagnosis is based on their small size, the absence of cephalic and caudal papillae, and the presence of a bulb-shaped anterior part of the esophagus which continues anteriorly in three flattened lobes projecting slightly from the mouth, and with a small esophageal gland situated in about the middle of the esophagus. These characters are not very important if the parasite is not mature, and they are therefore not very useful as diagnostic criteria. *Philometra parasiluri* Yamaguti, 1935 was described from the orbit of *Parasilurus asotus*, the typical host of *Clavinema*, which was found on the inside of the operculum and in the submaxillary connective tissue. The difference between the two genera is the absence of cephalic and caudal papillae and the presence of a small gland in the middle of the esophagus in *Clavinema*. Cephalic and caudal papillae are present in *Ph. parasiluri* and the esophageal gland is very large. Cephalic papillae may be absent, as in other species of *Philometra*, but the other characters depend on the length of the body, which depends on the development of the eggs and larvae in the uterus. The genus *Clavinema* cannot therefore be considered valid until mature specimens are found, and Rasheed suggests that it is a synonym of *Philometra* and *Clavinema parasiluri* a synonym of *Ph. parasiluri*. We agree with her.

Description (after Yamaguti, 1935).

Male unknown.

Female. Length to 34 mm, width 0.5 mm. Body threadlike, with almost truncate cephalic end. The head bears 8 large papillae with wide base, equally spaced at the anterior margin. Several indistinct accessory papillae are present on each side of the whole body. The conical muscular anterior part of the esophagus is 0.075–0.096 mm wide; its three anterior lobes project slightly from the mouth, which is 0.024–0.027 mm wide; the thin, cylindrical posterior part of the esophagus is 1.0–1.4 mm long, and its dorsal gland is well developed. Between the esophagus and the intestine is a small muscular ventricle, at the posterior end of which a lobed granular process projects into the intestine which ends posteriorly in a compact strand which is attached to the wall of the posterior end. Anus absent. Two distinct papillae 0.027–0.031 mm wide are present on the blunt tail.

The cylindrical, turned anterior and posterior ovaries are sometimes curved. The anterior ovary extends anteriorly to the nerve ring, which is situated about 0.12–0.2 mm from the cephalic end. The anterior end of the uterus is situated 0.27–0.31 mm from the cephalic end and its posterior end 0.34–0.8 mm from the end of the tail. Larvae in the uterus are 0.36–0.38 mm long and 0.09–0.012 mm wide. Vulva absent.

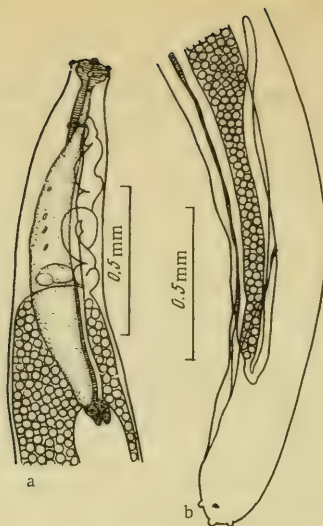


FIGURE 173. *Philometra parasiluri* Yamaguti, 1935:

a — anterior end of female, lateral; b — posterior end of female, lateral (after Yamaguti, 1935).

Yamaguti (1941) found in the orbital cavity of *Parasilurus asotus* a single mature female of *Philometra* 53 mm long and 0.75 mm wide in which he found, in addition to the two symmetrical terminal papillae, another 7 papillae at the posterior end (one dorsal, two subventral, and four lateral) and longitudinal rows of 2–5 smaller papillae; however, these are probably not always present.

307 Description (after Yamaguti, 1935, as *Ph. opsalichthydis*).

Female. Length 35–43 mm, width 0.5–0.53 mm. Eight cephalic papillae which are slightly flattened and 0.018–0.024 mm wide at the base. Two protruding caudal papillae 0.024–0.036 mm wide. Mouth 0.030–0.033 mm wide. The thickened muscular anterior part of the esophagus is 0.090–0.111 mm wide; its three convex papillae project slightly from the mouth; the cylindrical glandular posterior part of the esophagus is 0.83–1.32 mm long. Dorsal esophageal gland beginning behind the nerve ring. A muscular ventricle and its process present. Nerve ring situated 0.22–0.25 mm from the cephalic end. The intestine ends in a firm strand attached to the ventral body wall at the posterior end.

The cylindrical, sinuous ovaries, one at each end of the body, differ markedly in position: the anterior ovary usually begins before the uterus (in not fully mature females), the anterior end of which is situated 0.37–0.7 mm from the cephalic end; the posterior ovary sometimes extends almost to the end of the tail or begins before the posterior end of the uterus, which is situated 0.43–0.66 mm from the posterior end. The uterus contains numerous fully developed embryos with a long, thin tail which are 0.39–0.42 mm long and 0.009–0.012 mm wide.

References: Belous, 1965, pp. 48–65, Roitman, 1963b, pp. 263–312; Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 78; Yamaguti, 1935, pp. 352–356; 1941, p. 391; 1961a, pp. 217–228.

***Philometra pellucida* (Jägerskiöld, 1893)**
(Figure 174)

Synonym: *Ph. sebastisci* Yamaguti, 1941

Hosts: marine fishes *Tetradon stellatus*, *T. hispidum*, *Dactylopagrus macropterus*, *Belone liura*, *Sebastiscus marmoratus*.

Localization: testes.

Distribution: Australia, Japan.

Description (after Rasheed, 1965).

Male unknown.

Female. Length 45–85 mm, maximum width 0.6–1.0 mm. Body tapering at both ends, which are not pointed. Weakly developed papillae visible in apical view. Esophagus with wide lumen, its walls slightly wrinkled. Lumen of the esophagus widening, forming a "cavity" in its anterior, bulb-shaped part. Esophagus with strong muscles anteriorly which pass through the bulb. Length of esophagus 1.4–1.56 mm. Tail rounded, with two very small papillae.

The ovaries begin one at each end of the body. Uterus filled with developing eggs in young specimens, with larvae in mature forms. Larvae 0.33–0.4 mm long, 0.007 mm wide. The larvae are coiled into a ring.

(308)

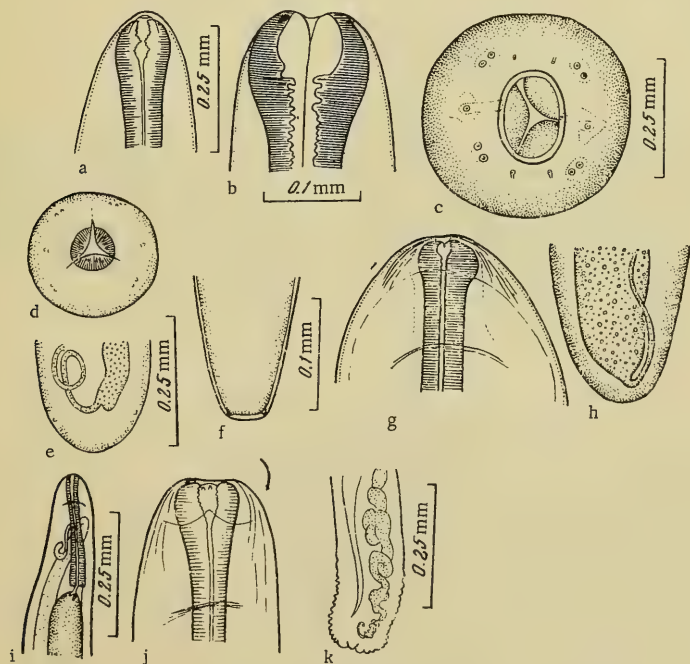


FIGURE 174. *Philometra pellucida* (Jägerskiöld, 1893):

a, b, c, d, g, j — cephalic end of female, different aspects; i — anterior end of female, lateral; e, f, h, k — posterior end of female, different aspects (after Rasheed, 1963, 1965).

Rasheed's description is the same as that of Jagerskiöld, except for 308 the smaller size, which Rasheed attributes to age differences and the immaturity of the specimens she examined.

Description (after Yamaguti, 1941, as *Ph. sebatisci*).

Male unknown.

Female. Length to 135 mm, width 2.0 mm. Coloration dark red, ends of body blunt. Cephalic and caudal papillae absent. Cuticle thin and wrinkled. Nerve ring situated 0.25–0.3 mm from the cephalic end. Esophagus 1.25–1.45 mm long and 0.12–0.17 mm wide in the widened anterior part. Esophageal gland and ventricle weakly developed. Anus absent. Ovaries 0.12–0.32 mm wide, extending anteriorly to the anterior bulb of the esophagus, beginning near the posterior end. Uterus filled with larvae in sheaths. Length of larvae 0.32–0.35 mm, width 0.015–0.020 mm, with a caudal spine 0.006–0.008 mm long. Nerve ring situated 0.048–0.057 mm from the cephalic end, esophagus and intestine differentiating, anus dividing the body at a ratio of 6–6.1:1.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 79; Jägerskiöld, 1893, p. 86; Rasheed, 1963, pp. 89–130; 1965, pp. 352–356; Yamaguti, 1941, p. 393; 1961b, p. 77.

309 *Philometra percalates* Johnston and Mawson, 1940
(Figure 175)

Host: *Percalates colonorum*.

Localization: body cavity.

Distribution: Australia.

Description (after Johnston and Mawson, 1940).

Male. Length 2.6 cm. Cephalic end rounded, with 8 small papillae. Esophagus 0.25 mm long, with widened anterior end, narrowed near the nerve ring, widened posteriorly. Nerve ring situated 0.15 mm from the cephalic end. Spicules 0.105 mm long, with narrow wings; gubernaculum 0.04 mm long, with wide apex. Tail truncate, with 4 lobes, the ventral pair of lobes longer and the dorsal pair more distinct.

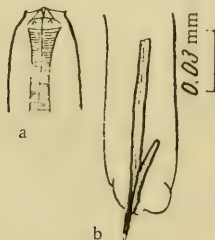


FIGURE 175. *Philometra percalates* Johnston and Mawson, 1940:

a — cephalic end; b — posterior end of male (after Johnston and Mawson, 1940).

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p.78; Johnston and Mawson, 1940, p.349; Yamaguti, 1961b, p.77.

Philometra pinnicola (Yamaguti, 1935) Yamaguti, 1941
(Figure 176)

Synonyms: *Sanguinofilaria pinnicola* Yamaguti, 1935; *Philometra serranelli-cabrillae* Janiszewska, 1949

Hosts: *Epinephelus akkara*, *Serranellus cabrilla*.

Localization: fins, ovaries.

Distribution: Japan, Europe.

Historical review

Ph. pinnicola was described in the genus *Sanguinofilaria* Yamaguti, 1935, which the author later (1941) considered as a synonym of *Philometra*.

Rasheed (1963) compared the description of *Ph. pinnicola* and *Ph. serranelli-cabrillae* Janiszewska, 1949, and stated that these species are very similar and that their hosts all belong to the family Serranidae and their distribution is also similar. She therefore made *Ph. serranelli-cabrillae* a synonym of *Ph. pinnicola*.

Description (after Yamaguti, 1935, 1941). Body cylindrical, dark red in life. Intestine narrow, without dark pigment granules in the epithelium.

Male unknown.

Female. Length 20–40 mm, width 0.65–1.25 mm. Nerve ring situated 0.15 mm from the cephalic end. Length of esophagus 1.0–1.25 mm, width at the anterior swelling 0.080–0.090 mm. Ovaries 0.055–0.11 mm wide, twisted around the ends of the uterus. Embryos with a sheath, with a brown tooth at the cephalic end; length of embryos 0.32–0.37 mm, width 0.02–0.025 mm.

Description (after Janiszewska, 1949, as *Ph. serranelli-cabrillae*).

Male unknown.

Female. Body threadlike, reddish to reddish brown, tapering at both ends. Length 32–60 mm. Cephalic and posterior end blunt; sensory papillae absent. Cuticle smooth. Width of body 1 mm in a large female. Esophagus cylindrical, 1.30 mm long and 0.15 mm wide at the widest point in females 60 mm long. "Pharynx" with a gland on the dorsal side which extends to half its length. Esophagus slightly widened anteriorly, passing through a small ventricle, which consists of glandular cells, and then with a small glandular process into the intestine. The intestine ends blunt in the posterior part, where it narrows and adheres to the body wall. It consists of large oblong cells and is filled with small reddish brown pigment granules. The intestine is markedly darker in adult than in young females. Nerve ring situated 0.37 mm from the cephalic end. The uterus forms a broad duct which occupies the entire width of the body cavity; it extends almost to the nerve ring and ends at the end of the esophagus.

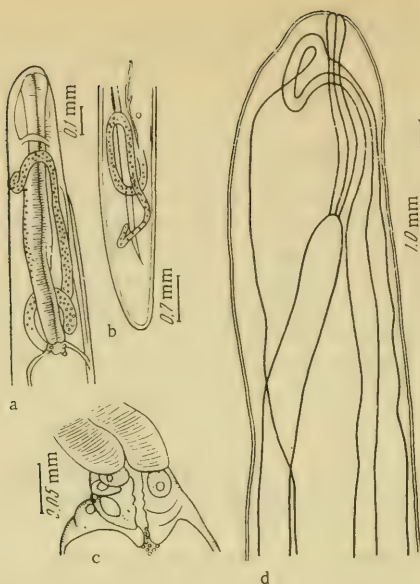


FIGURE 176. *Philometra pinnicola* (Yamaguti, 1935):

a — anterior end, lateral; b — posterior end, lateral; c — region of connection between esophagus and intestine; d — anterior end (a—c — after Janiszewska, 1949; d — after Yamaguti, 1935).

It is entirely filled with embryos. In mature females the uterus contains filarioid embryos 0.35 mm long and 0.07 mm wide. On each side of the uterus is an ovary which forms a more or less winding tube.

Females taken from the definitive host and placed in fresh water or in physiological saline break up rapidly.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 78; Janiszewska, 1949, pp. 7—20; Yamaguti, 1935, p. 360; 1941, p. 393; 1961b, p. 77.

311 *Philometra scomberesoxis* Nikolaeva and Naidenova, 1964
(Figure 177)

Host: *Scomberesox saurus*.

Localization: body cavity.

Distribution: Ionian and Tyrrhenian seas.

Description (after Nikolaeva and Naidenova, 1964).

Male unknown.

Female. Body thick, slightly tapering at the ends. Both ends of body blunt, without processes or sensory papillae. Cuticle smooth, with numerous small oval cells with large rounded nuclei below it. Such cells

are present throughout the body but they are particularly numerous at the ends. The reddish brown color of the body is due to a dark brown pigment in the wall of the intestine.

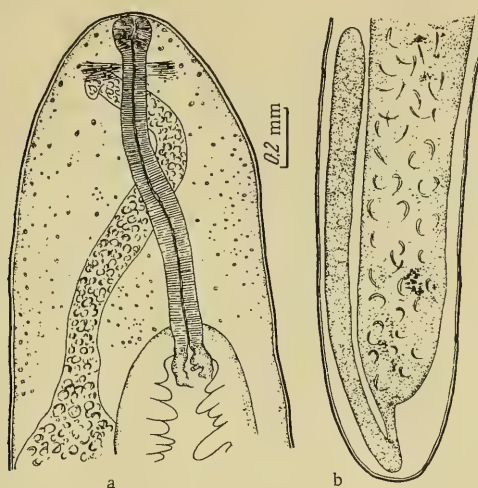


FIGURE 177. *Philometra scomberesoxis* Nikolaeva and Naidenova, 1964:

a — anterior end, lateral; b — posterior end (after Nikolaeva and Naidenova, 1964).

Pharynx small, with a large gland. Esophagus cylindrical, without widenings, distinct only in young females. Ventricle indistinct, but the esophagus passes into a glandular appendage which consists of several cells at the beginning of the intestine. Intestine wide, ending blind in the posterior part. Length 93.382 (77.00—105.240) mm. Width at the pharynx 0.396 (0.300—0.420) mm, at the nerve ring 0.555 (0.435—0.630) mm. Maximum width 1.812 (1.500—2.190) mm. Nerve ring situated 0.225 (0.120—0.315) mm from the cephalic end. Esophagus 0.900 mm long.

312 Uterus wide, occupying the entire body cavity. It begins below the end of the esophagus and ends posteriorly at the end of the intestine. Ovaries situated at both ends of the uterus. At the cephalic end the ovary makes a turn below the nerve ring and is directed posteriorly. In the posterior part of the tail it turns sharply anteriorly. Uterus large, filled with filarioid embryos (larvae). Length of embryos 0.470 (0.375—0.527) mm, width 0.018 (0.016—0.019) mm. Cuticle of mature females thin and loose; it ruptures easily and the larvae released move actively in sea water.

Young females. Coloration lighter than in adults, cream and slightly yellowish to light reddish brown. Length 38.0 (34.48—41.15) mm. Width at end of pharynx 0.256 (0.170—0.333) mm, at the nerve ring 0.428 (0.248—0.540) mm. Maximum width 0.794 (0.430—1.245) mm. Nerve ring situated 0.154 (0.084—0.255) mm from the cephalic end.

Esophagus 0.861 (0.630—0.990) mm long and 0.090 (0.074—0.11) mm wide. The entire body of young females is filled with blastomeres (eggs at various stages of cleavage). Embryos still absent. Vulva already atrophied. Ovary 1.590 mm long.

Reference: Nikolaeva and Naidenova, 1964, pp. 126—168.

Host: *Sebastodes joyneri*.

Localization: pectoral fin.

Distribution: Japan.

Description (after Yamaguti, 1941).

Male unknown.

Female. Length 5.45–5.54 mm, maximum width 0.3–0.37 mm in middle of body with blunt ends. Cephalic and caudal papillae absent. Nerve ring situated 0.12–0.13 mm from the cephalic end. Esophagus cylindrical, 0.24–0.27 mm long and 0.022–0.030 mm wide at the anterior widening. Ventricle cylindrical, 0.045×0.018–0.021 mm large, with a relatively large process projecting into the intestine. The intestine narrows into a short thread and extends to the posterior end. Anterior ovary threadlike, 0.070–0.090 mm long at the ventricle or beginning of the intestine. Posterior ovary 0.3–0.38 mm long, with a funnel-shaped thickening 0.032–0.045 mm wide around its narrower proximal end, which is directed anteriorly or posteriorly at the posterior end of the uterus. Uterus filled with embryos, narrowing slightly at both ends, extending from the anterior end of the intestine to near the posterior end. Older embryos are markedly narrower and longer than younger ones, 0.17–0.19 mm long and 0.003 mm wide.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 79; Yamaguti, 1941, p. 394; 1961b, p. 77.

313 *Philometra spari* Yamaguti, 1961 (Figure 178)

Host: *Sparus macrocephalus*.

Localization: swim bladder.

Distribution: Japan.

Description (after Yamaguti, 1961a).

Male unknown.

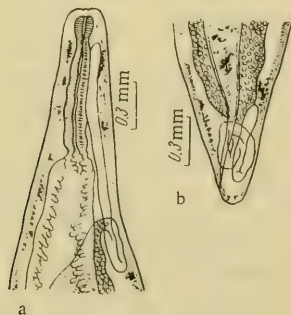


FIGURE 178. *Philometra spari* Yamaguti, 1961:

a — anterior end of female, lateral; b — caudal end of female, ventrolateral (after Yamaguti, 1961a).

Female. Length 110 mm, maximum width 1.4 mm at the cephalic end; body tapering at both ends. Cuticle with fine transverse striation. Head broadly rounded, without papillae. Esophagus 0.83 mm long, with a narrow dorsal gland which extends its whole length and apparently continues into the ventricular part, which is situated between esophagus and intestine; the bulblike anterior widening of the esophagus is 0.12 mm wide. Ventricle 0.065 mm long and 0.11 mm wide, consisting of gland cells filled with granules and ending in 3 valves which project into the intestine. Intestine narrowing posteriorly and ending blind, without an anus. Tail truncate, with 4 indistinct terminal papillae. The anterior ovary begins 0.22 mm from the cephalic end, turns posteriorly, winding before entering the uterus, which begins 1.5 mm behind the cephalic end and is filled with rounded eggs of varying size (0.013–0.026 mm). The posterior ovary makes two loops at the posterior end.

Reference: Yamaguti, 1961a, pp.217–228.

Philometra sydneyi Rasheed, 1963 (Figure 179)

Host: "large white fish."

Localization: subcutaneous tissue.

Distribution: Australia.

Description (after Rasheed, 1963).

Male unknown.

Female. Length 30–150 mm, width 0.35 mm. The cephalic end bears 8 papillae arranged in pairs in the outer ring and 4 papillae on the sub-
 314 median line in the inner ring. Amphids protruding, situated laterally. Cuticle smooth. Mouth wide, opening directly into the esophagus. Near

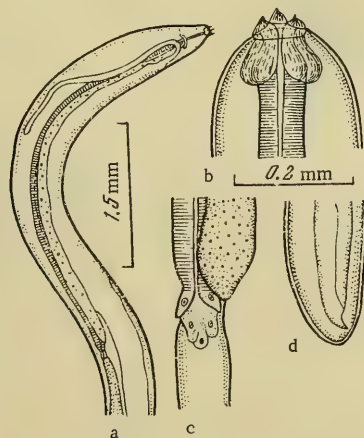


FIGURE 179. *Philometra sydneyi* Rasheed, 1963:

a — anterior end; b — cephalic end, showing esophageal teeth;
 c — end of esophagus; d — posterior end of female, lateral (after
 Rasheed, 1963).

the mouth the esophagus forms a bulb and continues anteriorly in three sharp teeth which are strongly chitinized. Length of esophagus 4.92 mm, width 0.15 mm at the anterior bulb. The large esophageal gland opens above the nerve ring and continues posteriorly to the end of the esophagus. Ventricle and process distinct. Nerve ring situated 0.3 mm from the cephalic end. Intestine of almost the same width as the posterior part of the esophagus, ending blind near the end of the tail.

Two long, thin ovaries, extending in opposite directions and uniting in the common duct of the uterus. Vulva absent. Tail slightly tapering. Larvae 0.36 mm long, 0.01 mm wide, with rounded head and pointed tail.

Reference: Rasheed, 1963, pp. 89–130.

Philometra tauridica Ivaschkin, Kovaleva, and Khromova n. sp.
(Figure 180)

Hosts: *Atherina mochon pontica*, *Trachurus mediterraneus ponticus*.

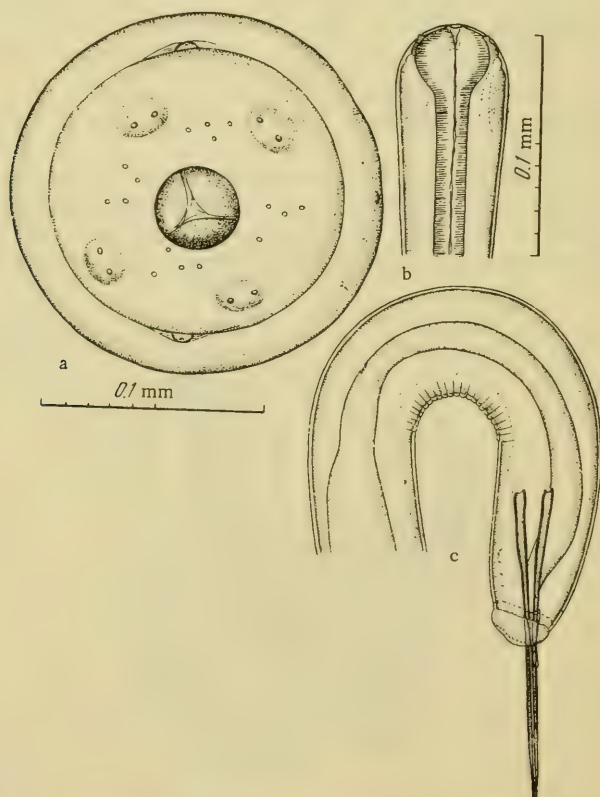


FIGURE 180. *Philometra tauridica* Ivaschkin, Kovaleva, and Khromova n. sp:
a — cephalic end, apical; b — anterior end; c — caudal end of male.

Localization: body cavity.

Distribution: Black Sea.

Description. Light yellow nematodes. Cuticle smooth. Cephalic end with papillae, visible in apical view: 8 papillae in the outer ring, arranged in pairs, and 16 papillae in the inner ring, arranged in groups of four. Esophagus entirely muscular, with an anterior widening. Nerve ring distinct. Uterus strongly developed, occupying the entire body cavity.

315 Male. Length 2.981 mm, width 0.054 mm. Length of esophagus 0.075 mm, width 0.011 mm. Nerve ring situated 0.034 mm from the cephalic end. Both spicules 0.088 mm long; gubernaculum 0.016 mm long.

Female (not fully mature specimens). Length 11.032–30.228 mm. Measurements of a female 17.032 mm long: width 0.416 mm, length of esophagus 0.731 mm, width 0.067 mm; length of esophageal swelling 0.101 mm; nerve ring situated 0.127 mm from the cephalic end.

Philometra zebrini Yamaguti, 1961 (Figure 181)

Host: *Zebrini zebrinus*.

Localization: subcutaneous connective tissue.

Distribution: Japan.

316 Description (after Yamaguti, 1961a).

Male unknown.

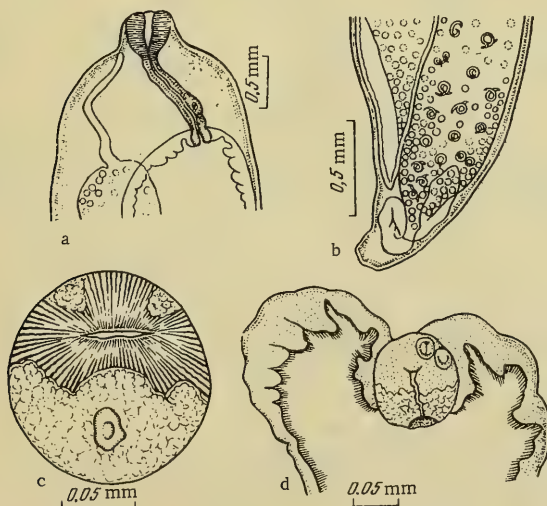


FIGURE 181. *Philometra zebrini* Yamaguti, 1961:

a — anterior end of female, lateral; b — tail of female, lateral; c — transverse section of esophagus at the thickening; the single dorsal and the paired subventral esophageal glands are shown; d — transverse section of connection between esophagus and intestine (after Yamaguti, 1961a).

Female. Length 30–35 mm, width 1.5–2 mm. Body cylindrical, blood-red in life. Cuticle smooth, transversely striated. The cephalic end usually projects markedly because the esophageal bulb projects anteriorly. Posterior end sometimes bilobed in mature specimens, but tapering in young specimens. Anterior esophageal bulb spherical, with triradial lumen, 0.3–0.5 mm wide; esophagus 0.1–0.16 mm wide, slightly widened behind its middle, where the lumen is flattened and displaced by the thick esophageal gland; subventral glands reduced at this point. The posterior end of the esophagus projects into the intestine and consists of a spongy parenchyma with large cells, appearing like a rudimentary ventricle. In the wall of the esophagus are two small, distinct vesicular structures which are probably swollen ducts of the esophageal glands, but they cannot be traced to the swollen part of the dorsal esophageal gland. At this part of the gland is a narrow duct with indefinite outline adhering to the nucleus; a distinct duct is not recognizable in the subventral gland. Intestine wide, ending blind near the caudal end.

The tubular anterior ovary 0.05–0.08 mm wide extends straight posteriorly from the esophageal bulb to the anterior end of the uterus. The uterus begins slightly behind the anterior end of the intestine in 317 young specimens but extends to the esophageal bulb in mature females. The posterior ovary is tubular, 0.09–0.13 mm wide and curves posteriorly around the posterior end of the uterus. Vulva absent. Length of larvae in uterus 0.41 mm, width 0.017 mm.

Reference: Yamaguti, 1961a, pp. 217–228.

Subgenus *Alinema* Rasheed, 1963

Diagnosis. Philometra. Mouth surrounded by a row of cuticularized moniliform structures. The wide lumen of the anterior part of the esophagus is surrounded by 3 large lobes which occupy almost the entire width of its anterior part. Tail slightly pointed. Parasites of freshwater fish.

Type species: *Philometra (Alinema) alii* Rasheed, 1963.

Philometra (Alinema) alii Rasheed, 1963 (Figure 182)

Hosts: *Pimelodus* sp., *P. pati*, *Pirinampus* sp., *P. pirinampus*.

Localization: mesentery, intestine.

Distribution: Brazil.

Description (after Rasheed, 1963).

Male unknown.

Female. Length 150 mm, width 0.37 mm. Cephalic papillae indistinct. An inner ring of submedian papillae is apparently absent. Mouth wide, the entire slit covered with moniliform cuticularized formations. The mouth passes directly into the wide esophagus; its three lobes occupy

318 the whole anterior part of the esophagus and project markedly. Nerve ring surrounding esophagus 0.37–0.4 mm from the cephalic end. Esophagus completely muscular, 0.95–1.8 mm long, its posterior end with a muscular ventricle with a small process into the intestine. Intestine ending blind at the posterior end.

Tail tapering. An ovary at each end of the body which is connected with the blind tube of the uterus; mature females have no oviduct or vulva. Uterus distended with larvae, which have a rounded head and pointed tail. Length of larvae 0.38–0.40 mm, width 0.020–0.023 mm.

Description (after Inglis and Ogden, 1964).

Male. Length 6.43–7.26 mm, width 0.10–0.16 mm. Width of head 0.044–0.053 mm. Cephalic papillae very small, cuticle smooth. Length of esophagus 0.40 mm. Tail rounded, with two pairs of protruding papillae and a pair of very small papillae. One pair of the protruding papillae is situated behind the cloaca; the other pair is situated almost at the end of the tail. The pair of small papillae is situated between and slightly before them. Spicules thin and simple, right spicule twice as long as the left. Right spicule 0.69–0.83 mm long, left spicule 0.36–0.41 mm. Gubernaculum long, 0.10–0.12 mm long, a distinct denticle at the posterior end.

(317)

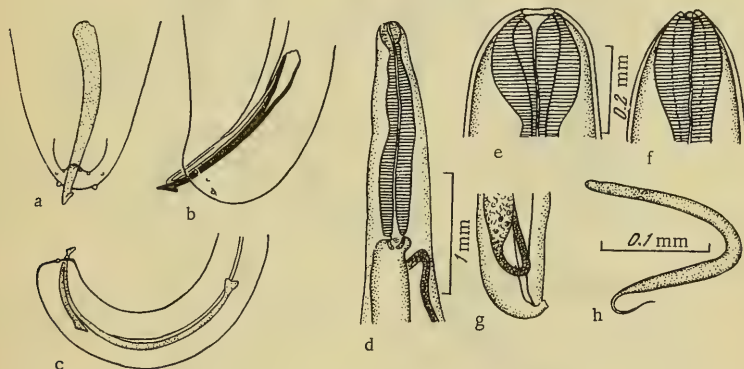


FIGURE 182. *Philometra (Alinema) alii* Rasheed, 1963:

a — posterior end of male, ventral; b — same, lateral, left side; c — same, lateral, showing the left spicule; d — anterior end of female; e — cephalic end, lateral; f — same, dorsoventral; g — caudal end of female; h — larva (a–c — after Inglis and Ogden, 1964; d–h — after Rasheed, 1963).

Female. Length 46.8–93.2 mm, width 0.44–0.53 mm. Width of head 0.09–0.12 mm. Length of esophagus 1.23–1.49 mm.

References: Inglis and Ogden, 1964, pp. 523–525; Rasheed, 1963, pp. 89–130.

Subgenus *Ranjhinema* Rasheed, 1963

Diagnosis. *Philometra*. Eight fleshy lobes arranged in four pairs on the submedian line; each lobe with two papillae of the same size

with small nerve endings. A pair of lateral amphids. The anterior part of the esophagus resembles an inverted flask with wide bottom. Tail with two large papillae at the end. Males unknown. Parasites of marine fish.

Type species: *Philometra* (*Ranjhinema*) *polynemii* Rasheed, 1963.

***Philometra* (*Ranjhinema*) *polynemii* Rasheed, 1963**
(Figure 183)

Host: *Polynemus tetradactylus*.

Localization: body cavity.

Distribution: Pakistan.

Description (after Rasheed, 1963).

Male unknown.

(319)

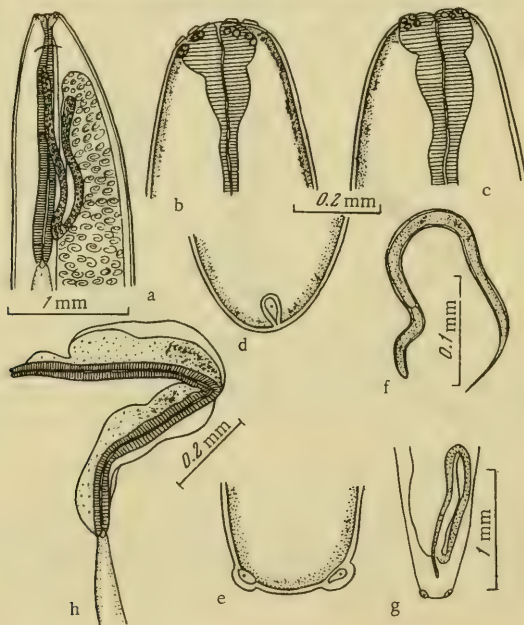


FIGURE 183. *Philometra* (*Ranjhinema*) *polynemii* Rasheed, 1963:

a — anterior end of female, lateral; b — cephalic end, dorsoventral; c — same, lateral; d — caudal end of female, lateral; e — same, ventral; f — larva; g — posterior end of female, lateral; h — details of esophagus (after Rasheed, 1963).

Female. Length 50–60 mm, width 0.9–1.2 mm. Cuticle smooth, but transverse fibers are distinct at some points and form bundles so that they appear like transverse bands below the cuticle.

Cephalic end rounded, width 0.21–0.26 mm, with 8 fleshy papillae situated submedially in four pairs and a pair of lateral amphids. The papillae have two lobes, and since they are fleshy, the nerve endings are difficult to see. Nerve ring surrounding the esophagus 0.23–0.26 mm from the anterior end. The esophagus has the form of a flask, with the base around the mouth; it then becomes slightly narrower and its width remains almost the same its entire length except at the posterior end, where it becomes again wider; it is widest in the anterior part. Length of esophagus 2.04–2.08 mm, width 0.16–0.18 mm. There is a large esophageal gland which extends to the end of the esophagus and opens near the nerve ring. Ventricle small, weakly muscular; intestine ending blind at the posterior end.

Tail rounded, with two large papillae at the end. Anus and vulva atrophied. Ovaries opposite, thin and long, uterus filled with larvae 0.38–0.39 mm long, 0.015–0.016 mm wide.

Reference: Rasheed, 1963, pp. 89–130.

320 Genus *Buckleyella* Rasheed, 1963

Diagnosis. Philometrinae. Body cylindrical, with blunt, narrowing ends. Head with large lobelike papillae and a pair of amphids. Cuticle with rodlike structures arranged in a definite order, with grooves below them. Esophageal gland with a membrane. Ventricle and process present. Esophagus bulb-shaped at the anterior end, the three lobes projecting into chitinated teeth. Intestine ending blind. Ovaries opposite. Anus and vulva atrophied. Tail blunt, rounded, with two lateral papillae. Males unknown. Parasites of marine fish.

Type species: *Buckleyella buckleyi* Rasheed, 1963.

Buckleyella buckleyi Rasheed, 1963 (Figure 184)

Host: *Chorinemus tala*.

Localization: mesentery.

Distribution: Pakistan.

Description (after Rasheed, 1963).

Male unknown.

Female. Length 46–110 mm, width 0.3–0.5 mm. Body of uniform width its entire length, with tapering ends. There are sharp, needle-shaped or rodlike structures arranged in a definite order projecting from the cuticle. Below these structures are fibrillar formations in the form of warts which become more distinct when the body contracts and are difficult to see in extended specimens and in females distended with larvae; on the other hand, the "rods" are more conspicuous in females filled with larvae.

321 The cephalic end bears 8 oblong, flat, lobe-shaped papillae and a pair of amphids which are characteristic for this genus. Width of cephalic end 0.17–0.19 mm. Nerve ring situated 0.25–0.3 mm from the cephalic end. The esophagus begins at the mouth; it has a bulb-shaped widening

at the anterior end and continues anteriorly in three cuticularized teeth which project from the slit-shaped mouth. These teeth are pointed and are distinct in young forms; they are used for piercing blood vessels and tissues.

(320)

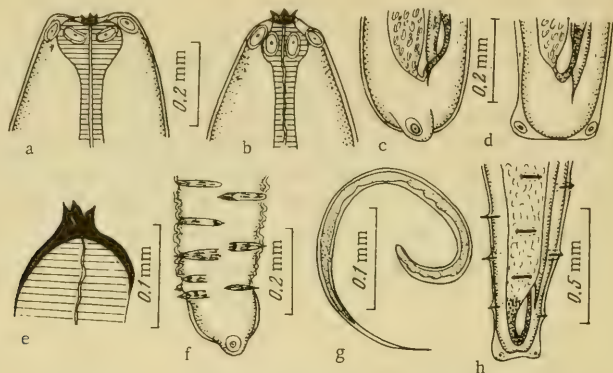


FIGURE 184. *Buckleyella buckleyi* Rasheed, 1963:

a — cephalic end, showing the slightly retracted esophageal teeth, dorsoventral; b — same, another specimen; c — tail of female, lateral; d — same, dorsoventral; e — section of esophagus of a young female, showing esophageal teeth; f — posterior end of female, showing the "warts" (contracted specimen); g — larva; h — tail of female, dorsoventral, showing the rodlike formations (after Rasheed, 1963).

Esophagus entirely muscular, 3.96–5.1 mm long, width 0.14–0.15 mm at the anterior bulb. The esophageal gland is not very distinct and has a membrane; ventricle indistinct. The intestine has a reticulate epithelium and ends blind at the posterior end. Anus absent.

Tail rounded, with two large lateral papillae so that the tail appears bifid in some specimens.

Two ovaries, situated near the caudal and cephalic end, passing into the uterus, which is filled with larvae. Larvae large, with rounded cephalic end and sharply tapering tail, 0.39–0.48 mm long, maximum width 0.0125–0.015 mm.

Reference: Rasheed, 1963, pp. 89–130.

Genus *Ichthyofilaria* Yamaguti, 1935

Diagnosis. Philometrinae. Body cylindrical, with pointed ends. Mouth simple. Esophagus divided into a muscular anterior part with two swellings separated by the nerve ring and a short posterior part with a glandular appendage projecting into the intestine. Between the two parts of the esophagus is a long, vermiform gland which ends in the anterior part of the intestine. This becomes narrower posteriorly, where it is not functional, continuing in a tube to the end of the body. Anterior ovary rudimentary; posterior ovary cylindrical, extending to the posterior end of the body and returning to the uterus. Uterus containing larvae.

Parasites of the body cavity of fish.

Type and only species: *Ichthyofilaria dasycotti* Yamaguti, 1935.

Ichthyofilaria dasycotti Yamaguti, 1935
(Figure 185)

Host: *Dasycottus setiger*.

Localization: body cavity.

Distribution: Japan.

Description (after Yamaguti, 1935).

Male unknown.

Female. Length 30.43–38 mm, width 0.5–0.8 mm. Body cylindrical, pointed at both ends. Nerve ring situated obliquely, 0.18–0.246 mm from the cephalic end. Mouth simple, Esophagus divided into a muscular anterior part and a short posterior part which is 0.29–0.348 mm long. The esophagus has two thickenings which are divided by the nerve ring and which are of varying width (0.12–0.18 mm) according to the contraction of the body. The posterior part of the esophagus is narrower than the anterior part and forms a small glandular appendage which projects into the intestine. Dorsal to the connection of the two parts of the esophagus is a long, vermiform gland containing a few nuclei. The irregularly widened intestine contains amorphous reddish brown inclusions and forms posteriorly a narrow, nonfunctional tube which ends blind in an awl-shaped swelling at the end of the tail. Anterior ovary atrophied into a vermiform process 0.15 mm long, posterior ovary cylindrical, 2.94 mm long and 0.19 mm wide. The wide, tubular uterus begins 3.31 mm from the cephalic end and 3.35 mm from the posterior end. Uterus filled with larvae 0.160–0.180 mm long and 0.003 mm wide. Vagina and vulva not recognizable.

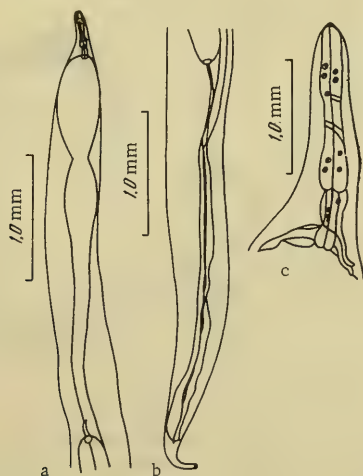


FIGURE 185. *Ichthyofilaria dasycotti* Yamaguti, 1935:

a — anterior end; b — posterior end; c — cephalic end (after Yamaguti, 1935).

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 80; Yamaguti, 1935, pp. 357-358; 1961b, p. 78.

Genus *Nilonema* Khalil, 1960

Diagnosis. Philometrinae. Large nematodes, body with tapering, pointed ends. Cuticle with large conical processes. Esophagus cylindrical, without an anterior widening. Cephalic papillae small. Ovaries opposite. Anus and vulva atrophied. Males unknown. Parasites of freshwater fish.

Type species: *Nilonema gymnarchi* Khalil, 1960.

Nilonema gymnarchi Khalil, 1960 (Figure 186)

Host: *Gymnarchus niloticus*.

Localization: swim bladder.

(323)

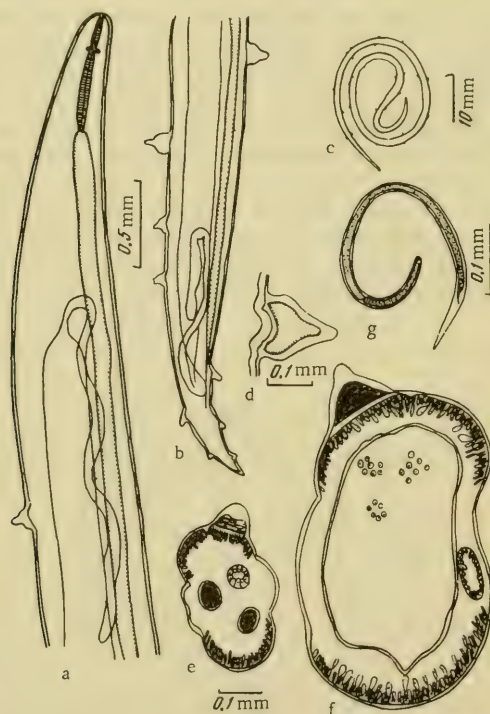


FIGURE 186. *Nilonema gymnarchi* Khalil, 1960:

a - anterior end of female, lateral; b - tail of female, lateral; c - adult female, lateral; d - cuticular conical process; e - transverse section of posterior part of female; f - same, in middle of body; g - larva (after Khalil, 1960).

Distribution: Sudan.

Description (after Khalil, 1960).

Male unknown.

Female. Length of largest specimen 115 mm, width 1.2 mm. Body of almost uniform width its entire length, with pointed ends. Cuticle relatively thick, with numerous irregularly distributed conical, teatlike processes. The number of these structures is very variable and depends to some extent on the size of the specimen. There were 75 on the largest specimen. The anterior processes are situated near the cephalic end and are scattered irregularly on the dorsal and ventral side of the body. They are more numerous and are arranged more densely in the caudal region to the end of the tail. Their size decreases toward the end of the tail, but it is more or less constant in the middle of the body, where they are 0.16–0.27 mm high and 0.15–0.3 mm wide at the base.

Mouth simple, opening directly into the short, cylindrical, muscular esophagus which is 0.57–0.81 mm long and 0.05–0.06 mm wide. Esophageal gland absent. Nerve ring situated 0.18–0.27 mm from the cephalic end. Intestine with relatively thick walls, wider than the esophagus. Its lumen becomes gradually narrower posteriorly and finally disappears, the intestine forming a cord which is attached to the body wall.

The long, cylindrical, curved ovaries are situated at each end of the body. Posterior ovary usually sinuous. The two ovaries are connected with the uterus by a narrow oviduct. Uterus large, with thin walls, occupying almost the entire body cavity. Vagina and vulva absent. Length of larvae 0.48–0.54 mm, width 0.014 mm. Cephalic end blunt, tail long and pointed; intestine, esophagus and anal pore are visible.

Reference: Khalil, 1960, pp. 55–58.

Nilonema senticosa (Baylis, 1927) Rasheed, 1963
(Figure 187)

Synonyms: *Philometra senticosa* Baylis, 1927; *Philometroides senticosa* (Baylis, 1927) Travassos, 1960

Host: *Arapaima gigas*.

Localization: body cavity.

Distribution: South America.

Historical review

Nilonema senticosa was described from the swim bladder of *Arapaima gigas* in Brazil and was placed in the genus *Philometra*. Travassos (1960) transferred the species to the genus *Philometroides* Yamaguti, 1935. Rasheed (1963), after a study of Baylis' types in the British Museum and specimens of *Nilonema gymnarchi* Khalil, 1960, showed that the characters of *Philometra senticosa* resembled those of *Nilonema* more than those of *Philometroides*. Rasheed thought that the general habitus, the conical tubercles on the cuticle, the cylindrical esophagus, and the absence of a large esophageal gland prove that Baylis' species belongs to *Nilonema* and not to *Philometroides*.

Description (after Baylis, 1927b).

Male unknown.

Female. Length 90–125 mm, width 0.62–0.85 mm. Cephalic end markedly more pointed than posterior end. Cuticle thick, apparently consisting of two layers. It bears a row of spinelike processes with a refracting surface. Under high magnification, these uneven outgrowths all over the body, including the anterior part of the esophagus, make the nematode look like a stem of bramble.

Cephalic end rounded [sic], mouth simple, without lips. Cephalic papillae indistinct. Esophagus indistinctly divided into a muscular and a glandular part, very narrow anteriorly, except for a slight widening around the mouth before the nerve ring. Behind the nerve ring the esophagus gradually widens into a club. A narrow "neck" separates the esophagus from the intestine. Three valves between esophagus and intestine. The esophagus is apparently enclosed in a granulate membrane. Length of esophagus 1.37–1.5 mm. Nerve ring situated 0.35–0.4 mm from the cephalic end; slightly behind it is the small, semitransparent excretory pore, which is apparently connected with a group of cells in the body wall. The intestine extends almost through the whole body in the form of a wide tube formed by 325 large cells. The intestine apparently ends blind, adhering to the body wall. Vulva absent. Branches of uterus opposite, forming a continuation of the tube which extends almost from one end of the body to the other and is connected at each end with the short, coiled ovaries. Viviparous. Uterus filled with larvae with blunt cephalic end and markedly pointed, conical tail.

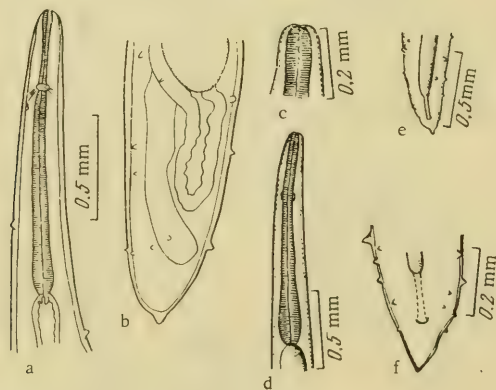


FIGURE 187. *Nilonema senticosa* (Baylis, 1927):

a — anterior end of female, lateral; b — posterior end of female, lateral;
c — cephalic end; d — anterior end; e, f — posterior end, ventral (a, b —
after Baylis, 1927b; c–f — after Travassos, 1960).

Description (after Travassos, 1960).

Male unknown.

Female. Length 60–130 mm, width 0.41–0.71 mm. Cephalic end blunt, without ornamentation. Posterior end conical. Cuticle with distinct transverse striation and large conical spines of varying size (0.043–0.073 mm)

irregularly distributed from the end of the esophagus to the anus. Musculature polymyarian, body with narrow, indistinct longitudinal fields. The esophagus begins at the mouth, which is a triangular slit without formations. Esophagus club-shaped, consisting of a cylindrical anterior part and a widened posterior part. Length of esophagus 1.2–1.4 mm, width 0.12–0.157 mm. Nerve ring situated in the cylindrical part, at its anterior third. Intestine cylindrical, dark. It ends in a narrow but permeable rectum. Anus situated 0.063–0.081 mm from the posterior end. Genitalia amphidelphic. The anterior ovary forms several loops at the end of the esophagus. The posterior ovary extends to the anus. Uterus large, saclike, occupying the entire body cavity, pressing the intestine to the side and the ovaries to the ends of the body. Females filled with first-stage larvae. Vulva and ojector not found. Larvae in uterus about 0.300 mm long, width 0.014 mm.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 79; Baylis, 1927b, pp. 35–47; Rasheed, 1963, pp. 89–130; Travassos, 1960, pp. 15–20.

326 Genus *Philometroides* Yamaguti, 1935

Diagnosis. Philometrinae. Body cylindrical, long, with blunt ends and numerous cuticular thickenings on the cuticle. Parietal muscle cells strongly developed on the dorsal and ventral side and distinctly flattened in the peripheral zone. Cephalic and posterior end without papillae. Mouth simple. Esophagus partly swollen anteriorly, with a well-developed dorsal esophageal gland and a muscular ventricle, and also with a glandular appendage which projects into the intestine. Intestine, ovary, uterus, and larvae resembling those of *Philometra*.

Viviparous. Parasites of marine fish.

Type species: *Philometroides seriola* (Ishii, 1931).

Philometroides seriola (Ishii, 1931)
(Figure 188)

Synonym: *Filaria seriola* Ishii, 1931

Hosts: marine fishes.

Localization not given.

Distribution: Japan.

Description (after Yamaguti, 1935).

Male unknown.

Female. Length 38 mm, width 1.7 mm. Body of about the same width its entire length, blunt at the ends, cuticle thick, with irregularly scattered flattened, teatlike thickenings. The muscle cells of the surface are strongly developed, particularly on the dorsal and ventral side; their peripheral compressed part is platelike and stains strongly with eosin. The two granular midlines are narrow in dorsoventral view and elongate in transverse section. The flattened wide lateral fields consist of fine fibrils with

numerous nuclei. Mouth simple, opening into the slightly swollen, cylindrical muscular anterior part of the esophagus which is 4.6 mm long, with a large, dorsal gland beginning at the nerve ring, 0.4 mm from the cephalic end.

(326)

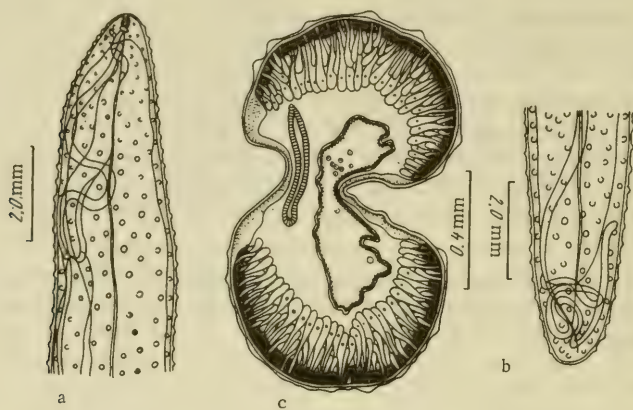


FIGURE 188. *Philometroides seriolae* (Ishii, 1931):

a — anterior end; b — posterior end; c — transverse section (after Yamaguti, 1935).

Length of gland 3.6 mm, width 0.4 mm. The muscular ventricle with a small glandular appendage projects into the intestine. Ovary long and thin, extending to the ends of the body. The uterus contains embryos 0.6 mm long, with thin tail. Vagina and vulva absent.

Description (after Yamaguti, 1941). Body cylindrical, long, with blunt ends and numerous cuticular thickenings. Cephalic and posterior end without papillae. Mouth simple. Esophagus partly swollen anteriorly, with a well-developed dorsal gland and a muscular ventricle, and also with a glandular appendage which projects into the intestine.

Male unknown.

Female. Length 38 mm, width 1.7 mm. Body of about the same width its entire length, blunt, cuticle relatively thick, with irregularly scattered, flattened, teatlike thickenings. Length of esophagus 4.6 mm. Nerve ring situated 0.4 mm from the cephalic end. Ovary long and thin, extending to the ends of the body. The uterus contains embryos 0.6 mm long. Vagina and vulva absent. Viviparous.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 79; Ishii, 1931, p. 207; Yamaguti, 1935, pp. 355–356; 1941, pp. 343–396.

Philometroides anguillae (Ishii, 1916) Rasheed, 1963
(Figure 189)

Hosts: *Anguilla rainhardtii*, *A. japonica*.

Localization: body cavity.

Distribution: Queensland.

Historical review

The nematode from the eye orbit of *Anguilla japonica*, described as *Filaria anguillae* Ishii, 1916, was transferred by Yamaguti (1935) to the genus *Philometra*. Rasheed, who knew the description of Ishii and the illustrations, found that her specimens and Ishii's species were similar. Yamaguti stated that there were 6 cephalic papillae, two lateral and two on the dorsal and two on the ventral side. Rasheed found 8 distinct cephalic papillae and a pair of amphids.

Ishii illustrated two protruding papillae at the posterior end, but in Rasheed's specimens the tail was almost rounded; only in one specimen she found two papillae on the ventral surface; the papillae were indistinct in the other two specimens. Except for the difference in the number of papillae, the species of Ishii resembles *Ph. anguillae* in all respects. The genus of host is also the same.

Description (after Rasheed, 1963).

Male unknown.

Female. Length 88–100 mm, width 0.7–0.8 mm. Cuticle smooth, but under high magnification several tubercles are visible near the tail and numerous tubercles scattered on other parts of the body. Body of uniform width its entire length except at the ends, where it tapers slightly.

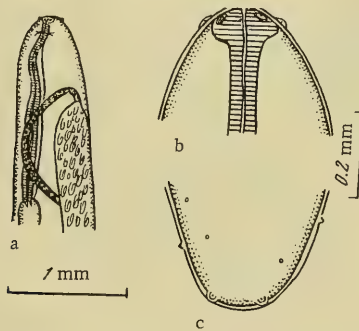


FIGURE 189. *Philometroides anguillae* (Ishii, 1916) Rasheed, 1963:

a — anterior end of female, lateral; b — cephalic end of female, lateral;
c — posterior end of female, dorsoventral (after Rasheed, 1963).

Cephalic end with 8 papillae and a pair of amphids. Length of esophagus 1.59–1.62 mm, width of the swollen anterior part 0.17–0.19 mm. There is a small ventricle with a process projecting into the intestine. Nerve ring situated 0.18–0.20 mm from the cephalic end. Anus absent, intestine ending blind near the posterior end.

The anterior ovary forms loops above the esophagus; posterior ovary situated near the posterior end. Uterus filled with fully developed eggs and embryos, which are 0.43–0.47 mm long and 0.010–0.012 mm wide.

Tail rounded, with two papillae situated ventrally, near the end of the tail.

References: Rasheed, 1963, pp. 89–130; Yamaguti, 1935, pp. 347–386.

Philometroides denticulatus Rasheed, 1965
(Figure 190)

Hosts: *Pristipoma hasta*, *Otolithus ruber*.

Localization: body cavity, swim bladder.

Distribution: Pakistan.

Description (after Rasheed, 1965). Coloration yellowish white. Body tapering at both ends. Cuticle thin, with prominent warts on the whole body which are formed only by the cortical layer of the cuticle. Under the cortical layer is a small point or nucleus in the wart which sometimes appears like the pore of an amphid.

Male unknown.

(329)

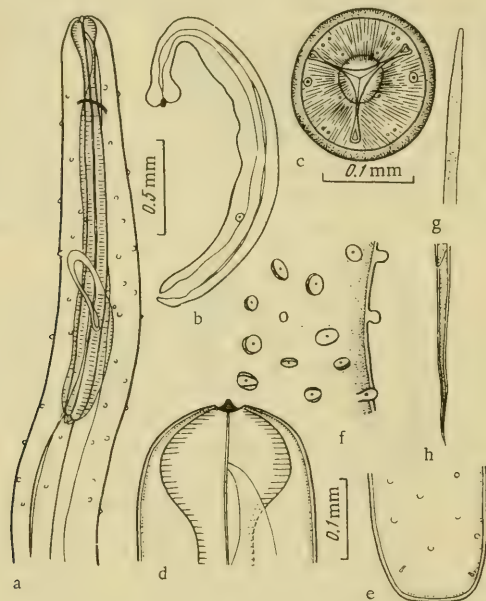


FIGURE 190. *Philometroides denticulatus* Rasheed, 1965:

a - anterior end, lateral; b - esophagus, removed from body; c - cephalic end, apical;
d - cephalic end; e - posterior end of female, ventral; f - papillae on part of the cuticle;
g - anterior end of larva; h - posterior end of larva (after Rasheed, 1965).

Female. Length 250–320 mm, width 0.52–0.67 mm. Esophagus thickened anteriorly in the form of a bulb, which projects from the mouth in three small parts resembling teeth. On each side of the anterior part of the esophagus there are muscles which probably move the esophagus. Cephalic papillae very small and difficult to see. Length of esophagus 1–2.15 mm. Esophageal gland saclike, with a large nucleus in the middle, extending along the entire esophagus and opening slightly before its widening, about 0.060 mm from the cephalic end. The esophagus is not divided posteriorly and is connected with the intestine by small valves. Nerve ring surrounding esophagus 0.38–0.45 mm from the cephalic end.

The ovaries begin at the ends of the body and continue into the curved, saclike uterus, which is filled with larvae 0.63–0.73 mm long and 0.009–0.011 mm wide. Some larvae which have been discharged from the female already have a rudimentary genital duct and an anus situated 0.1 mm from the end of the tail. Toothlike formations and two laterally protruding papillae are present at the cephalic end.

Tail rounded; two small papillae present at its end. Anus absent.

Reference: Rasheed, 1965, pp.349–362.

330 *Philometroides lusiana* (Vismanis, 1966), n. comb.
(Figures 191, 192)

Synonyms: *Philometra lusii* Visman, 1962; *Philometra lusiana* Vismanis, 1966

Host: *Cyprinus carpio*.

Localization: under scales, in scale pouches, body cavity, wall of swim bladder.

Distribution: USSR.

Historical review

This species was described in 1962 as *Philometra lusii* Visman, 1962, but since there were mistakes in the original description of the female, the author redescribed the species and, in accordance with the rules of nomenclature, renamed it *Ph. lusiana* Vismanis, 1966.

Description (after Vismanis, 1967, as *Philometra lusiana*). Males markedly shorter than mature females (ratio about 1:50).

Male. Length 2.9–3.5 mm, width 0.038–0.045 mm. Body almost of uniform width its entire length, tapering at the ends. Anterior end narrower than posterior end. Width of anterior end 0.015–0.016 mm at the pharynx, width of posterior end 0.024–0.027 mm at the terminal widening. Cuticle smooth, thin. Cephalic end rounded. Mouth apical. Posterior end slightly curved ventrally and widened, forming collarlike formations in two spongelike lobes. Intestine opening at the posterior end, and the pointed spicules projecting subterminally. Spicules 0.19 to 0.23 mm long; their width in the middle about 0.0027 mm. Gubernaculum 0.051–0.062 mm long, slightly curved, with a characteristic tooth at the distal end which resembles a pointed arrow. Length of tooth 0.0079–0.0084 mm.

Female. Length 115 mm, width 1 mm. Females are pink or red in life, threadlike. Cuticle with numerous papillae 0.014–0.025 mm long scattered irregularly on the whole body. There are about 2000 papillae on a female 70 mm long.

Body tapering at both ends. Anterior end with 4 cephalic papillae. Mouth trihedral, leading into the esophagus, which is straight with a slight widening anteriorly. In a female 9 cm long and 0.8 mm wide, the esophagus is 2 mm long and 0.07–0.09 mm wide. Intestine brownish red, narrowing posteriorly and ending blind. Anus and vulva atrophied in adults.

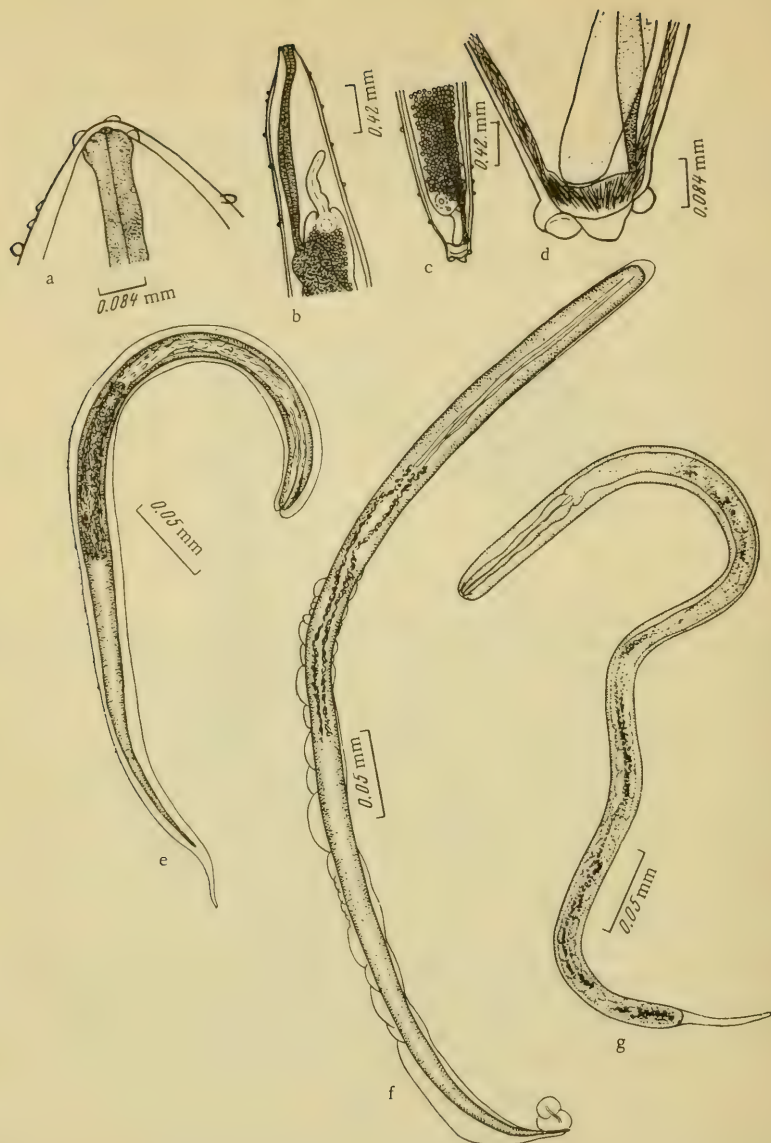


FIGURE 191 *Philometroides lusiana* (Vismanis, 1966):

a — cephalic end; b — anterior end, lateral; c — posterior end of female; d — posterior end of female; e — larva from *Cyclops* during first molt; f — same, during second molt; g — fourth-stage larva from the swim bladder of carp 23 days after infection (a—d — after Vismanis, 1966; e—g — after Vasil'kov, published for the first time).

Posterior end with 4 paired processes of different size and form. Two of them are distinct processes of the body at the end of the tail. They are about 0.04 mm long. Between them are two smaller cuticular lateral processes, one of which is sometimes small. Nerve ring situated 0.165–0.242 mm from the cephalic end in females 6–9 cm long.

The entire body cavity of mature females is occupied by the uterus, which contains numerous rounded eggs, 0.034 to 0.040 mm wide at the end of winter. The eggs have a thin shell. The larvae develop in May. Ovaries small, cylindrical, with smooth surface, situated at both ends of the body. Viviparous.



FIGURE 192. *Philometroides lusiana* (Vismanis, 1966):

a — anterior end of female; b — posterior end of female; c — posterior end of male;
d — carp infected with *Ph. lusiana* (after Vasil'kov, published for the first time)

Young, unfertilized females and males are found in the body cavity and in the wall of the swim bladder during the copulation period. The females closely resemble the males in size. Young females 2.3 to 3.5 mm long, width at the genital pore 0.0297–0.0375 mm. Surface smooth, without papillae. Ends of body rounded, cephalic end slightly more pointed than the posterior end.

333 In young females the intestine is well developed and opens at the posterior end. After fertilization, the body of the female becomes covered with small papillae, cephalic and caudal papillae develop, the genital pore and anus atrophy. The larvae grow in the uterus in spring. When they come into contact with water, mature females break up and the larvae are released. Length of larvae 0.40–0.47 mm, width 0.015–0.019 mm. The larvae are threadlike, with thin, smooth cuticle. Their cephalic end is blunt and rounded, the tail pointed.

Biology. Vismanis (1964) studied the life cycle of the parasite. He found that it lasts a year, from June to May. Intermediate hosts may be any of the following: *Macrocyclus albidus*, *Eucyclops ser-rulatus*, *E. macruroides*, *Mesocyclops leuckarti*, and *Cyclops strenuus*. The larvae grow in the body cavity of the host. They molt after 3–4 days; development in the intermediate host lasts 6–7 days, and the larvae then become infective. Carp become infected in June when they swallow infected water fleas. The copepods are digested and the larvae are released, penetrate through the wall of the intestine and enter the body cavity. Five days later they concentrate around the swim bladder, gonads, and kidneys and grow and develop into males and females. This lasts about one month, and the females are then fertilized. At this time the young forms are of about the same length: females 2.3 to 3.5 mm, males 2.9 to 3.5 mm.

After fertilization of the females, the males penetrate into the wall of the swim bladder; the females leave the body cavity and move to their permanent location in the scale pouches, where they are found at the end of June or in early July. The females grow rapidly: they are 4–8 mm long at the end of June – early July, 30 mm in early August, 60 mm in October–November, and 100–110 mm in the following spring.

In the middle of May, when the water temperature is 11°C, larvae begin to develop and become 0.4–0.45 mm long.

In Latvia, the larvae are released into the water at the end of May – early June when the water temperature is 15–20°C.

Vasil'kov (1968b) gave data on the life cycle of the species in the central regions of the RSFSR; he used in his experiments *Acantho-cyclops viridis*, *A. vernalis*, *Eucyclops macruroides*, *Cyclops strenuus*, and *Mesocyclops leuckarti* as experimental intermediate hosts.

The larvae molt first after 3–4 days; the second molt takes place after 7–8 days, and they are then 0.60–0.65 mm long. In the intestine of the definitive host, they penetrate into the wall of the intestine and then into the body cavity; 5–8 days after infection, the larvae are localized on the serosa and after 14–15 days in the liver and kidneys, where they molt the first time in the definitive host. After 18–21 days the larvae are found in the wall of the swim bladder and molt the second time; after 30–40 days sexual differentiation has ended, and the larvae are 2.9–4.5 mm long. Fertilization now takes place.

334 At the end of August and in September the females move into the scale pouches, where they remain throughout autumn, winter and spring (8–9 months). The males remain in the swim bladder. Vasil'kov found that the life of females lasts 11–12 months and of males 13–14 months.

Vismanis stated that *Ph. lusiana* is at present widely distributed in the European Soviet Union; infections have been recorded in pond fisheries in Latvia, Belorussia, European Russia, and the Ukraine. Vasil'kov (1964, 1967a, b, 1968) found the disease in carp in the Kaliningrad, Minsk, Ternopol, and Moscow regions.

The clinical symptoms of the disease appear when the parasites enter the scale pouches and are as follows: small tubercles with slight hemorrhages appear on the anterior part of the body. Damaged, swollen scales often form a kind of collar around the head. In places where the nematodes come into contact with the scales the pigment of the scales is partly destroyed, forming a kind of imprint of the worm.

When the larvae enter the water in spring, the points of localization become red, so that they appear like ulcers observed in erysipelas.

The nematodes have a toxic effect on the carp and apparently feed on the blood of the host (Vasil'kov, 1964).

All ages of carp contract the disease, but yearlings and two-year-olds are most heavily infected (to 70–90%). The intensity of infection is also high, 25–35 specimens (to 50–75). If a young fish contains more than 3 nematodes it dies; it probably cannot tolerate the migration of fertilized females from the body cavity to their permanent location in the scale pouches. Carp one and two years old infected with *Philometroides* have a low commercial value and are usually rejected.

During the migration, the larvae increase in size and molt; hemorrhages are found in the intestine, liver, and swim bladder. Infected fish do not attain standard weight and are usually sluggish.

Diagnosis is made by finding the parasites in the scale pouches. Where tubercles and raised scales are found the scales are taken with a forceps and the parasites are found coiled under them, singly or sometimes in twos or threes. Adult females are found from the hemorrhages, swollen scales, imprints of the parasites on the scales, and their visibility through the scales. On the venter, where the scales are white, the nematodes are clearly recognizable. The parasites are usually found on the head and opercula, sometimes in the tissue of the operculum and in the eye orbit.

Vismanis and Vasil'kov recommend the following measures of prevention and control:

1. Transport of carp for breeding purposes from farms where the disease is prevalent should be forbidden.
- 335 2. Rearing and foraging ponds in which infected fish are found should be cleaned and kept without water during the winter.
3. In main ponds, which supply water to other ponds, older carp should not be released to feed.
4. To prevent infection of young fish, stock from the spawning ponds should be removed immediately after spawning.
5. Young fish should be removed from the spawning ponds not later than 6 days after spawning, because the larvae of *Ph. lusiana* are not infective for 6 days.

Vasil'kov obtained good results with the following anthelmintics: diethylcarbamazine citrate and ditrazine base (30 or 40% aqueous solution)

for the treatment of spawners and young stock. He recommends doses of 0.3–0.4 g/kg of weight; the fish are treated in spring, 2–3 weeks before spawning, or in autumn, during transfer to the wintering ponds, at a water temperature of 12–14°C; the preparation is less effective at lower temperatures.

References: Ivashkin and Khromova, 1965, pp.98–99; Kuz'movich, 1964, pp.66–67; Vasil'kov, 1967a, pp.449–452; 1967b, pp.62–64; 1968a, pp.53–56; 1968b, pp.28–30; Vismanis, 1962, pp.93–96, 1964, pp.192–193; 1966, pp.9–10; 1967, pp.759–761.

Philometroides maplestoni (Travassos, Artigas, and Pereira, 1928) Rasheed, 1963 (Figure 193)

Synonym: *Philometra maplestoni* Travassos, Artigas, and Pereira, 1928

Host: *Salminus hilarii*.

Localization: body cavity.

Distribution: Brazil.

Description (after Travassos, Artigas, and Pereira, 1928, as *Philometra maplestoni*).

Male unknown.

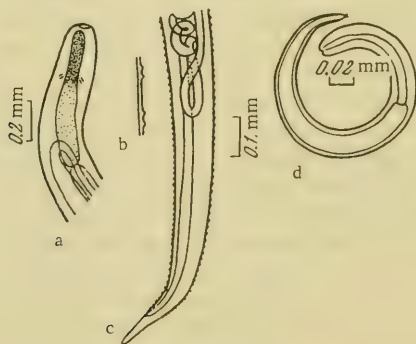


FIGURE 193. *Philometroides maplestoni* (Travassos, Artigas, and Pereira, 1928):

a — anterior end of female, lateral; b — detail of cuticle;
c — tail of female, lateral; d — larva (after Travassos, Artigas,
and Pereira, 1928).

Female. Length 144 mm, width 0.22 mm; cuticle with small processes irregularly distributed on the whole body. Mouth rounded, without an armature; esophagus divided into a thinner anterior part about 0.28 mm long and 0.05 mm wide and a posterior part 0.43 mm long and 0.10 mm wide.

Anus very small; situated 0.048 mm from the posterior end; rectum very thin, difficult to find. Tail finger-shaped, posterior end tapering from the end of the genital ducts, about 0.65 mm from the posterior end. Vulva not found; loops of genitalia extending to the end of the esophagus anteriorly. Nerve ring situated in the posterior part of the anterior part of the esophagus.

Embryos about 0.320 mm long and 0.18 mm wide, esophagus already differentiated, about 0.100 mm long, tail ending in a widening in the form of a racket, so that it appears bifid.

Reference: Travassos, Artigas, and Pereira, 1928, p. 27.

Philometroides masu (Fujita, 1940) Rasheed, 1940
(Figure 194)

Synonym: *Philometra masu* Fujita, 1940

Host: *Oncorhynchus masou*.

Localization: body cavity.

Distribution: Japan.

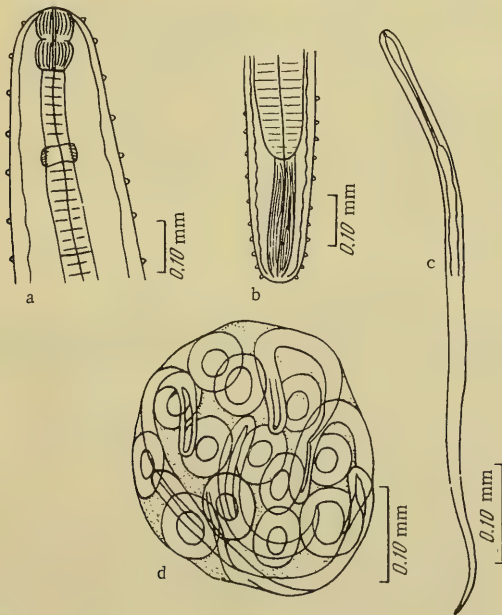


FIGURE 194. *Philometroides masu* (Fujita, 1940):

a — cephalic end, dorsal; b — posterior end; c — larva; d — eggs and larvae (after Fujita, 1940).

337 Description (after Fujita, 1940, as *Philometra masu*).
Male unknown.

Female. Length 16.5–63.0 mm, width 0.32–0.85 mm. Cuticle thin, with numerous small papillae irregularly scattered on the body. Cephalic end rounded, mouth simple, without lips. Length of pharynx 0.11 mm, width 0.08 mm in a female 16.50 mm long. Pharynx constricted in the middle and longitudinally striated on the whole surface. Anterior part of esophagus 0.46 mm long, posterior part 0.99 mm, width 0.17 mm. Intestine 14.68 mm long, 0.13 mm wide anteriorly, ending blunt 0.26 mm from the posterior end. Rectum and anus atrophied. Nerve ring situated 0.34 mm from the cephalic end.

Vulva and vagina atrophied in mature females. The vulva may be found with difficulty in the anterior third of the body in some immature specimens. Uterus single, with thin wall, wide and straight, 13.12 mm long and 0.28 mm wide. Ovaries paired, opposite; anterior ovary 2.50 mm long, turned posteriorly before the posterior part of the esophagus; posterior ovary 2.25 mm long, ending 0.18 mm before the end of the tail. Eggs oblong, 0.040 mm wide. Larvae threadlike, 0.75 mm long and 0.03 mm wide, with a distinct thick-walled esophagus and anterior part of the intestine.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 77; Fujita, 1940, pp. 389–390; Yamaguti, 1941, p. 393; 1961a, pp. 217–218, 1961b, p. 76.

***Philometroides nodulosa* (Thomas, 1929) Dailey, 1967**
(Figure 195)

Synonym: *Philometra nodulosa* Thomas, 1929

Hosts: *Catostomus commersoni*, *Huro salmoides*.
Localization: body cavity.
Distribution: North America.

Historical review

Thomas found a single mature female of this species in 1927 and studied experimentally some aspects of development of the nematode. Dailey (1967) recorded the species from the head of *Catostomus commersoni*. He described the male (description not available). Dailey identified it as *Philometroides nodulosa* (Thomas, 1929) Dailey, 1967.

Description (after Thomas, 1929, as *Philometra nodulosa*).
Male unknown.

Female. Length 28 mm, width 0.456 mm. Body brilliant white in life. The body tapers from the middle toward both ends, cephalic end rounded, posterior end truncate. High, light-refracting processes on the cuticle. They are uniformly distributed on the entire surface so that they form rows of incomplete rings; distance between rings 0.004–0.124 mm. Height of processes 0.006 mm, length 0.415 mm. Cuticle transversely 338 striated. Three layers of the cuticle can be distinguished after triple staining after Mallory: an outer layer less than 0.001 mm thick and two layers 0.002 mm thick together.

Mouth terminal, surrounded by 6 small lips situated in a shallow depression. The dorsal and ventral lips are sometimes turned back and slightly larger than the lateral lips.

Esophagus with muscular anterior part in the form of a bulb which extends for 0.010 mm. This widening is 0.049 mm wide and behind it the esophagus is 0.040 mm wide and weakly muscular. Before and dorsal to the widening there is a small glandlike body. The esophagus is connected with the wide, degenerating intestine 0.15 mm wide which gradually narrows and extends near the body wall. Anus absent.

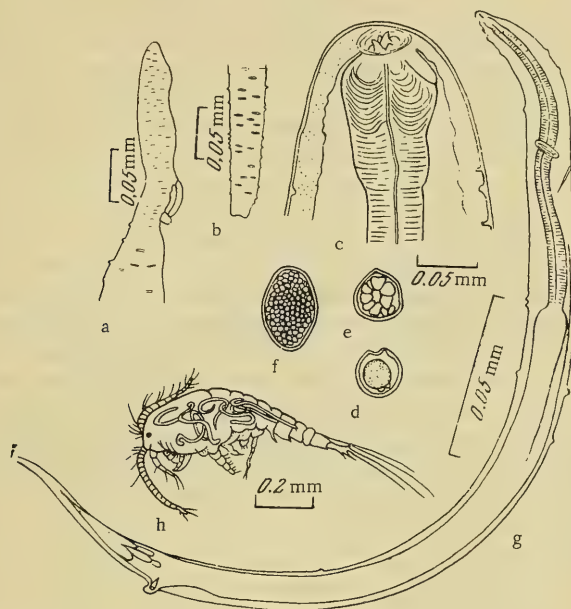


FIGURE 195. *Philometroides nodulosa* (Thomas, 1929):

a - anterior end of female, lateral; b - posterior end of female, ventral;
c - cephalic end; d-f - eggs from uterus at different stages of development;
g - larva from uterus; h - *Cyclops brevispinosus* infected with
larvae (after Thomas, 1929)

The shorter anterior ovary is 0.332 mm wide. Posterior ovary rudimentary. Uterus filled with mobile larvae and eggs at different stages of development. Eggs with thin hyaline shell, ovoid in the early stages, 0.012×0.014 mm large.

Lateral lines wide and distinct, about 0.014 mm wide in middle of body. About 54 muscle fibrils on each side of the dorsal or ventral nerve extend into the body cavity, forming muscular margins at the sides. The muscle strands extend almost to the midline of the lateral fields and are visible 339 after modified triple staining after Mallory.

Description of larvae from the uterus. Length 0.316 mm. All larvae of the same size. Width 0.006 mm 0.002 mm from the cephalic end. The body becomes conical and pointed, tail threadlike, with small papillae at the end. Cuticle finely striated.

Anus situated on the ventral surface, 0.048 mm from the posterior end. A convexity is present around the anus.

Two lips around the mouth, one dorsal and one ventral. Esophagus thin, occupying anterior third of body. Intestine wide, distinct because of the presence of strongly refracting granules. Large cells present which may be developing gonads. Two indistinct dark brown bodies in the middle of the intestine. Segmented glands at the posterior end, opening 0.040 mm from end of tail.

Life cycle. Thomas (1929) observed that when the cuticle of a female bursts in the water, the larvae are released; they are very mobile; some adhere to the bottom with the tail, coiling into a spiral. Under experimental conditions, the larvae survive 1–3 days in water. Thomas observed that *Cyclops brevispinosus* swallowed the larvae, which increase in size in the host and remain viable 6–7 days, until the *Cyclops* dies. Experiments to infect the definitive host with these parasites were negative, probably because the larvae did not become infective in the *Cyclops*.

Dailey (1967) reported successful infection of *Cyclops vernalis* and *C. thomasi* with larvae of *Ph. nodulosa*; the larvae reached the third stage after 20 days in the host. Dailey also successfully infected the definitive host. He found third-stage larvae in the swim bladder and kidneys 9 days after infection. The larvae moved at first ventrally and then anteriorly, to the head during the fourth and fifth stages. Copulation was observed at the early fifth stage in females and during the anterior migration in mature males. The males then died, but the fertilized females continued to grow. The entire development lasts 146–365 days, depending on the temperature. Dailey stated that the parasites are only slightly pathogenic for the definitive host.

References: Dailey, 1967, pp. 1266–1267; Thomas, 1929, pp. 193–199.

Philometroides plectroplites (Johnston and Mawson, 1940)
Rasheed, 1963 (Figure 196)

Synonym: *Philometra plectroplites* Johnston and Mawson, 1940

Host: *Plectroplites ambiguus*.

Localization: body cavity.

Distribution: Australia.

340 Description (after Johnston and Mawson, 1940, as *Philometra plectroplites*).

Male unknown.

Female. Length over 105 mm. Cuticle with numerous irregularly scattered warts. Cephalic end rounded, without lips or papillae. Length of esophagus 1.05 mm, width 0.09 mm; its widened anterior part contains a small, almost hemispherical vestibule 0.048 mm long and 0.056 mm wide. Nerve ring situated 0.2 mm from the cephalic end. Vulva and anus atrophied. The large uterus occupies almost the entire body cavity; it passes into the oviduct about 0.5 mm from the cephalic end. Length of larvae in the uterus 0.47 mm, width about 0.022 mm; they are coiled into two spiral turns. Cephalic end of larvae rounded, posterior end pointed.

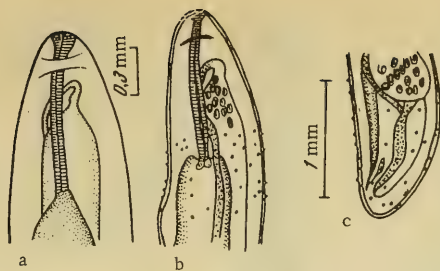


FIGURE 196. *Philometroides plectroplites* (Johnston and Mawson, 1940) Rasheed, 1963:

a — anterior end; b — same, lateral; c — posterior end of female, lateral (a — after Johnston and Mawson, 1940; b, c — after Rasheed, 1963).

Description (after Rasheed, 1963).

Male unknown.

Female. Length 105 mm, cuticle with numerous irregularly scattered tubercles. Cephalic papillae present. Esophagus widened anteriorly, 1.2 mm long and 0.2 mm wide in the widened part. Nerve ring situated 0.2 mm from the cephalic end. Uterus filled with larvae coiled into a spiral; larvae 0.45–0.47 mm long and 0.022–0.023 mm wide. Tail rounded.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 78; Johnston and Mawson, 1940, p. 349; Rasheed, 1963, pp. 89–130.

Philometroides sanguinea (Rudolphi, 1819) Rasheed, 1963 (Figure 197)

Synonyms: *Filaria sanguinea* Rudolphi, 1819; *Philometra sanguinea* (Rudolphi, 1819); *Philometra trilabiata* Belouss, 1965; *Ph. carassii* Ishii, 1933

Hosts: *Carassius carassius*, *C. auratus gibelio*.

Localization: fins.

Distribution: Europe, Asia.

Historical review

This species was described by Rudolphi (1819) as *Philometra sanguinea*, which he found under the skin of the caudal fin of *Cyprinus gibelio* (= *Carassius auratus gibelio*). Rudolphi's description was not very detailed; he only stated that the body is rounded, blood-red, both ends blunt, and that the posterior part is more slender in the females. 341 Later authors therefore recorded red nematodes found in various freshwater fishes as *Philometra sanguinea*, although they were localized in the body cavity.

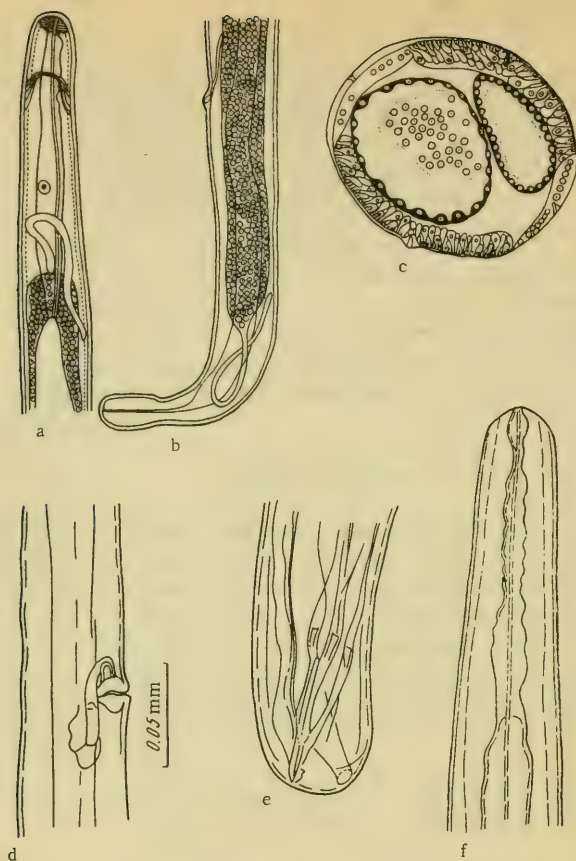


FIGURE 197. *Philometroides sanguinea* (Rudolphi, 1819):

a — anterior end; b — posterior end of female, rudiment of vagina visible; c — transverse section at the rudimentary vagina; d — genital pore of young female, lateral; e — posterior end of male; f — anterior part of a young form (a-c — after Mirza, 1929; d-f — after Wierzbicki, 1960).

Linstow (1902, 1909) gave a long list of the hosts of this species: *Carassius vulgaris*, *Leuciscus rutilus*, *Abramis brama*, *A. vimba*, *Blicca bjorkna*, *Osmerus eperlanus*, *Anguilla vulgaris*, *Cottus gobio*; as localizations he gave the body cavity, but for *Abramis vimba* under the skin of the operculum. Linstow gave a more detailed and specific description of *Ph. sanguinea*: coloration red, esophagus very short, cephalic end with 4 papillae. Length of male 2.3 mm, width 0.036 mm. Length of female 40 mm, width 1 mm. Length of spicules 0.24 mm. Length of larvae in uterus 0.5 mm, width 0.026 mm.

In an examination of specimens of *Carassius*, Nybelin (1928) found between the rays of the caudal fin females 40 mm long which he determined as *Philometra sanguinea*. He stated that the cuticle is covered with

numerous papillae. In 1931, after examination of the original material of Rudolphi in the Berlin Museum, he found that even badly preserved specimens show the cuticular papillae characteristic for the species on the whole body and stated that *Ph. sanguinea* is a specific parasite of *Carassius*. Nybelin established that Rudolphi's description applies only to parasites localized in the fins, and he proposed naming nematodes from the body cavity of species of Cyprinidae *Philometra abdominalis* Nybelin, 1928.

In a study of the helminth fauna of freshwater fishes in Sweden in 1928, Nybelin found in the pectoral fins of *Abramis farenus* and under the skin of the opercula in *A. blicca* nematodes which he did not identify as *Ph. sanguinea* because the cuticle was not quite smooth and the posterior end, unlike in *Philometra ovata* (Zeder), was bifid, not rounded, and the cephalic end bore 4 well-developed papillae. In 1931, convinced that these nematodes are distinct from *Ph. sanguinea* and *Ph. ovata*, Nybelin named them *Philometra opercularis* Nybelin, 1931. He also stated that four species of *Philometra* occur in European freshwater fishes and gave the following key for their determination.

- A. Cuticle with numerous papillae. Localization in the caudal fin, rarely in the dorsal fin of *Carassius* *Philometra sanguinea* Rudolphi, 1819.
- B. Cuticle smooth.
 - 1. Posterior end bifid. Localization under the skin in the anterior part of the body, pectoral fins, opercula, gills *Philometra opercularis* Nybelin, 1931.
 - 2. Posterior end rounded. Parasites of the body cavity
 - a) Length about 40–60 mm. Coloration red *Philometra abdominalis* Nybelin, 1928 (= *sanguinea* auct.).
 - b) Length to 125 mm. Coloration yellowish white *Philometra ovata* (Zeder).

A high rate of infection of *Carassius* with *Philometra sanguinea* was observed by Wierzbicki (1960) in Poland, by Čakay (1957) in Czechoslovakia, Molnár (1966b) in Hungary, and by Vismanis and Nikulina (1968) in the USSR; all these authors mention the strict specificity of the parasite for *Carassius*, since in lakes where *Carassius* were found infected other species of fish were free of infection.

Vismanis and Nikulina (1968) examined the original material of *Philometra sanguinea* from *Carassius auratus* in ponds in the Shipun District of the Altai Territory and from Poland, compared the descriptions of *Ph. sanguinea*, *Ph. trilabiata* Belouss, 1965, and *Ph. carassii* Ishii, 1933, and came to the conclusion that all these species are identical and made *Philometra carassii* Ishi, 1933 and 343 *Philometra trilabiata* Belouss, 1965 synonyms of *Philometra sanguinea* Rudolphi, 1819. We agree and, in accordance with Rasheed (1963), transfer this species to the genus *Philometroides*, Yamaguti, 1935.

Description (after Skrjabin, 1923a, as *Philometra sanguinea*).

Male. Length 2.3 mm, width 0.036 mm. Tail ending in two lobes; spicules 0.24 and 0.197 mm long; end of spicules pointed.

Female. Coloration blood-red. Length 40 mm, width 1.0 mm. Length of esophagus 1.56 mm. Intestine ending blind near the posterior end. Larvae in the uterus 0.5 mm long and 0.26 mm wide.

Description (after Dogel' and Akhmerov, 1959, as *Philometra sanguinea*).

Male not described.

Female. Length 10–35 mm. Cephalic end with a hemispherical process, at the apex of which the mouth is situated. The process has a strong musculature and around its base is a muscular collar which is apparently formed by four modified cephalic tubercles which have become fused. The cephalic part narrows slightly posteriorly, forming a short neck, and then begin small papillae, more than 150, which are irregularly distributed but show a tendency to form two lateral rows, particularly toward the ends of the body. Papillae pedunculate, partly embedded. The body is widest behind the head and tapers posteriorly. Length of esophagus 1.33 mm. In young forms the sides of the posterior end bear a paired process which resembles a caudal fin with a crescent-shaped notch between the two halves.

Wierzbicki (1960) described young forms of *Ph. sanguinea*. Young females are very small during the copulation period. Unlike in the adults, the cuticle is smooth in young males and females. There is a well-developed intestine, which later atrophies in females: the intestine becomes narrower and the anus closed completely.

Male. Length 3.1–3.3 mm. Posterior end with two spicules and a gubernaculum.

Female. Length 2.1–2.7 mm. At the posterior third of the body is a single tubercle, where the genital pore is situated; this atrophies after copulation.

Wierzbicki (1960) established that the life cycle of *Ph. sanguinea* lasts one year in nature. He found females in *Carassius* throughout the year but, according to the season, they were at different stages of development. The youngest females were found in the body cavity of the fish in the summer from May to October.

Fertilized females leave the body cavity. They do not appear in the fins until September; their number in the fins increases in autumn and winter. Almost all the parasites leave the fins in June.

Larvae which had left the uterus remained alive in water for 9 days and remained infective for 5 days. They were 0.37–0.40 mm long. They develop further in the body cavity of the intermediate host (*Cyclops kolensis* Lill.). After entering the water and then the intermediate and the definitive host, the larvae grow to 0.41–0.42 mm after 5 days, 0.44–0.46 mm after 10 days, 0.53–0.57 mm after 20 days, 0.65 mm after 33 days, and 1.02 mm after two months. The proportions of the body change with growth. The tail becomes shorter: it is 0.070–0.075 mm long when the larva enters the water, after 4 days it is 0.066–0.071 mm long, after 6 days 0.063–0.067 mm, and after a month in the body cavity of *Cyclops* the tail disappears. The width of the larva, on the other hand, increases with age. On the first day when they leave the female, the larvae are 0.001–0.013 mm wide, after 5 days 0.013–0.016 mm, and after 10 days 0.015–0.017 mm; the larvae of *Ph. sanguinea* are infective but they lose their infectivity after 14 days.

After the infective larvae enter the intestine of the definitive host, they penetrate its wall and move into the body cavity.

References: Belous, 1965, pp. 48–65; Dogel' and Akhmerov, 1959, pp. 287–304; Skrjabin, 1923a, pp. 1–98; Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, pp. 1–927; Vismanis and Nikulina, 1968, pp. 514–519; Čakay, 1957, pp. 909–914; Linstow, 1902, pp. 217–232; 1909, pp. 47–83; Molnár, 1966, pp. 227–241; Nybelin, 1928, pp. 1–4; 1931, pp. 58–64; Rasheed, 1963, pp. 89–130; Rudolphi, 1819, pp. 1–811; Wierzbicki, 1960, pp. 8–20; Wu, 1956, pp. 99–196.

Genus *Pseudophilometroides* Parukhin, 1966

Diagnosis. Philometrinae. Body cylindrical, long, with projecting anterior and rounded posterior end. Cuticle with numerous thickenings. Head with 8 papillae, tail without papillae. Mouth simple. Esophagus without an anterior swelling, with a well-developed, cylindrical dorsal gland. Anus and vulva atrophied. Viviparous. Parasites of marine fish.

Type species: *Pseudophilometroides atropi* Parukhin, 1966.

Pseudophilometroides atropi Parukhin, 1966

(Figure 198)

Host: *Atropus atropus*.

(345)

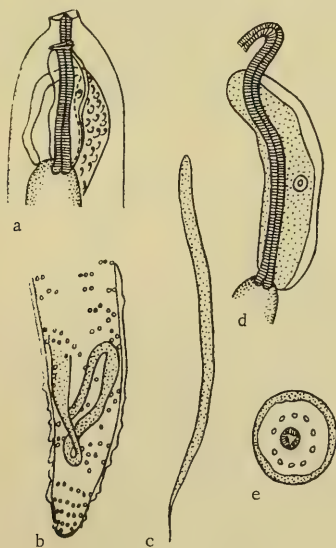


FIGURE 198. *Pseudophilometroides atropi* Parukhin, 1966:

a — anterior end of female; b — posterior end of female; c — larva;
d — esophagus and esophageal gland; e — cephalic end, apical (after
Parukhin, 1966).

Localization: body cavity.

Distribution: Gulf of Tonkin.

Description (after Parukhin, 1966).

Male unknown.

Female. Length 19.5–36.0 mm, width 0.645–1.125 mm. The entire body, except the anterior part, is densely covered with cuticular thickenings in the form of papillae. Cephalic region markedly projecting. Length of projecting part 0.20 mm, width 0.20 mm. Mouth simple. Cephalic end with 8 papillae and 2 amphids.

Esophagus without an anterior swelling, 1.2–1.65 mm long, 0.062–0.065 mm wide. There is an esophageal valve 0.093 mm long and 0.087 mm wide. On the dorsal side of the esophagus is a large cylindrical digestive gland 0.765 mm long and 0.18 mm wide; the gland begins in a slight indentation of the anterior margin of the esophagus and extends to the esophageal valve. Nerve ring situated 0.177 mm from the cephalic end. Uterus filled with larvae 0.495 mm long and 0.012 mm wide. Posterior end rounded. Anus and vulva atrophied.

References: Parukhin, 1966, pp. 766–767; Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, pp. 72–79; Rasheed, 1963, pp. 89–130.

Genus *Rumai* Travassos, 1960

Diagnosis. Philometrinae. Body cylindrical, with tapering ends. Head with apical processes with a concave surface between them and with 4 papillae. Cuticle smooth. Esophagus club-shaped, not swollen anteriorly. Tail conical. Males unknown. Parasites of freshwater fish.

Type species: *Rumai rumai* Travassos, 1960.

Rumai rumai Travassos, 1960 (Figure 199)

Host: *Arapaima gigas*.

Localization: body cavity.

Distribution: Amazon River.

346 Description (after Travassos, 1960).

Male unknown.

Female. Length 40 mm, width 0.64 mm. Cephalic end with a cuticular formation which appears like a pyramid in profile, while it is slightly concave in apical view. Four papillae are situated on this formation.

Average width of cephalic formation 0.16 mm. Length in lateral part 0.087 mm, at the mouth 0.075 mm. Cuticle smooth. Mouth leading directly into the esophagus. Esophagus large, club-shaped, its posterior end wider, with a wide lumen. Its anterior part is almost cylindrical; nerve ring situated near the mouth. Length of esophagus 2.51 mm, width in the posterior part 0.36 mm, in the anterior part, at the nerve ring, 0.144 mm. Nerve ring situated 0.315 mm from the cephalic end. Intestine apparently atrophied. Anus absent. Genitalia amphidelphic. Anterior ovary situated near the esophagus, opposite the uterus. Posterior ovary extending anteriorly from

the posterior end and partly concealed by the uterus. Uterus wide and saclike, occupying almost the entire body cavity. It is filled with first-stage larvae. Posterior end of body conical.

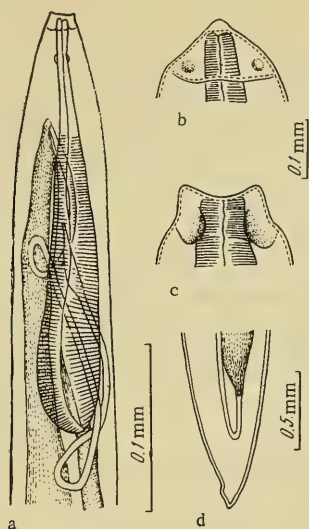


FIGURE 199. *Rumai rumai* Travassos, 1960:

a — anterior end, lateral; b, c — cephalic end, different aspects;
d — posterior end (after Travassos, 1960).

Reference: Travassos, 1960, pp. 15–20.

Genus *Thwaitia* Rasheed, 1963

Historical review

Thwaite (1927) described a nematode from the eye of *Balistes* sp. from Ceylon as "*Philometra* sp." Although he had only a few fragments of the cephalic and the posterior end, they permitted the description of the most important characters. Rasheed was interested in this material because of the strange form of the cephalic papillae. The material was placed at her disposal by Prof. Cashew of the University of Liverpool, where the type of the species described by Thwaite was deposited. It proved identical with the specimen in the British Museum.

After a detailed study of the material, Rasheed came to the conclusion that these nematodes belong to a new genus for which 4 cephalic papillae are specific, which are present only in a few genera and species of *Philometridae*. Linton (1901) described a nematode with 4 papillae as *Ichthyonema sanguineum*. Four cephalic papillae are also present in *Philometra abdominalis* Nybelin, 1928 (= *Ichthyonema*

347 *sanguinea* Linstow, 1874), *Ph. rischta* Skrjabin, 1917 (= *Ph. opercularis* Nybelin, 1931), *Ph. intestinalis* Dogiel and Bychowsky, 1934, *Ph. translucida* Walton, 1927, and *Ph. americana* Kuitunen-Ekbaum, 1933 in which the papillae are weakly developed.

Rasheed placed all these forms in the new genus *Thwaitia* Rasheed, 1963.

Molnár (1966b) thinks that *Ph. intestinalis* belongs to the family Skrjabillanidae Schigin and Schigina, 1958, although he accepts the classification of the family Philometridae proposed by Rasheed (Molnár, 1969). Moravec (1968) established the new genus *Molnaria* Moravec, 1968 of the family Skrjabillanidae in which he placed *M. intestinalis* (Dogiel and Bychowsky, 1934) Moravec, 1968 (= *Ph. intestinalis* Dogiel and Bychowsky, 1934). We also place *M. intestinalis* in the genus *Molnaria* Moravec, 1968.

Diagnosis. Philometrinae. Head with 4 large papillae in the outer ring. Inner ring indistinct or absent. Esophagus widened anteriorly. Ventricle present or absent. Tail blunt or rounded, with or without papillae. Males unknown. Parasites of freshwater and marine fish.

Type species: *Thwaitia balistii* Rasheed, 1963.

***Thwaitia balistii* Rasheed, 1963 (Figure 200)**

Synonym: *Philometra* sp. Thwaite, 1927

Host: *Balistes* sp.

Localization: eyes.

Distribution: Ceylon.

Description (after Rasheed, 1963).

Male unknown.

Female. Length to 210 mm, width 0.54–0.6 mm.

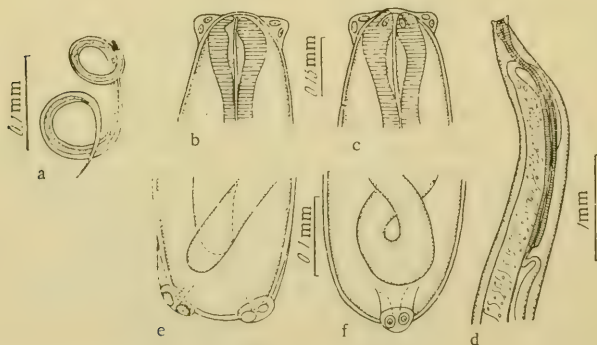


FIGURE 200. *Thwaitia balistii* Rasheed, 1963:

a — larva; b — cephalic end of female, lateral; c — same, dorsoventral; d — anterior end of female, esophagus, ovary, and uterus visible; e — posterior end of female, dorsoventral; f — same, lateral (after Rasheed, 1963).

Cephalic end blunt, appearing square in dorsoventral view; it bears large papillae which project laterally; width 0.18–0.19 mm. There are 4 flat lobes, each of which bears two fleshy papillae with indistinct nerve endings. These double papillae are situated on the submedian line; there is also a pair of small lateral amphids.

The anterior end of the esophagus is widened, narrowing to the nerve ring, and then of almost uniform width its entire length. Esophageal gland less distinct than in *Philometra*. Nerve ring surrounding esophagus about 0.14–0.15 mm from the cephalic end. Esophagus muscular its entire length, which is 2.04–2.34 mm; its width near the mouth is 0.09–0.17 mm. An esophageal ventricle or a process are absent. Intestine slightly wider than the posterior end of the esophagus, ending blind near the posterior end. Anus absent.

Tail rounded, with two wide lobes projecting laterally, each lobe with two papillae.

Two ovaries, one situated in the anterior, the other in the posterior part of the body. Their position is not constant and probably depends on the movements, state of preservation, or age of the worm. Uterus distended with larvae, which are very large: length 0.36–0.4 mm, width 0.017–0.019 mm. Their cephalic end is rounded and apparently bears two papillae. Cuticle with fine transverse striation; mouth opening into a wide intestine. Anus situated about 0.084 mm from the end of the pointed tail.

References: Shigin and Shigina, 1958, pp. 395–399; Linton, 1901, pp. 441–481; Molnár, 1966, p. 157; 1969, p. 137; Moravec, 1968, p. 322; Rasheed, 1963, pp. 89–130; Thwaitie, 1927, pp. 225–242.

Thwaitia abdominalis (Nybelin, 1928) Rasheed, 1963
(Figure 201)

Synonym: *Philometra abdominalis* Nybelin, 1928

Hosts: *Gobio gobio*, *Rutilus rutilus*, *Leuciscus idus*.

Localization: body cavity.

Distribution: USSR, Western Europe.

Historical review

The name *Philometra abdominalis* was given by Nybelin (1931) to separate mixed material which was placed under a single label together with *Philometra sanguinea* and had been identified as this species by Kreplin (1825), Diesing (1861), Linstow (1874), and other authors who had found these forms in various Cyprinidae. Nybelin did not give distinct differences between *Ph. abdominalis* and *Ph. ovata*, distinguishing them only according to color and size. Molnár (1967) studied typical specimens of *Ph. abdominalis* from *Gobio gobio*, and found that the males of these species are clearly distinguished by the form and size of the spicules and gubernaculum.

Rasheed (1963) transferred the species *Philometra abdominalis* to the genus *Thwaitia*.

Description (after Molnár, 1967, as *Philometra abdominalis*).

Male. Length 2.1–3.7 mm, width 0.037–0.057 mm. Cuticle smooth, cephalic end rounded, with 4 oblong papillae. Body of uniform width its entire length, except for a slightly narrower cephalic end. Posterior end blunt, with two lateral teatlike processes which are indistinctly connected dorsally.

Two spicules of almost the same length, moved by the gubernaculum. One spicule 0.127–0.172 mm long, the other 0.120–0.164 mm. Width of spicules 0.007 mm at the slightly thickened gubernaculum, 0.005 mm at the beginning, and 0.003 mm in the middle. Gubernaculum 0.53–0.65 mm long in the form of a curved chitinated plate with lanceolate end. There is a dorsal invagination in the form of a fringe in its distal part (however, this invagination is not as prominent as in *Ph. ovata*). Immediately after this invagination the gubernaculum is curved sharply dorsally and anteriorly.

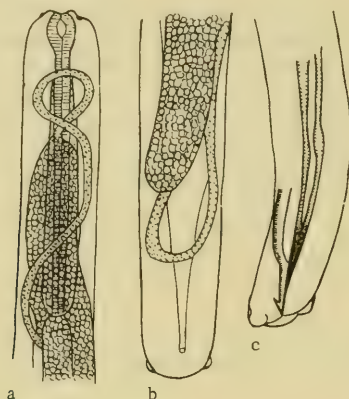


FIGURE 201. *Thwaitia abdominalis* (Nybelin, 1928):

a — cephalic end of female 3 months old; b — posterior end of female 3 months old; c — posterior end of male (after Molnár, 1967).

Female. Length 100–120 mm, width 0.9–1 mm. Adults red or yellowish red. Body cavity filled by the uterus. Cuticle smooth. Cephalic end rounded, with 4 slightly protruding papillae and 3 lips. Body cylindrical, of the same width its entire length. Caudal end rounded; two indistinct cuticular processes are visible on it in dorsoventral view. These processes are more distinct in young females 20–40 mm long.

The life cycle is completed in a year in the temperate zone, and the size of females in different seasons can therefore be determined with accuracy. According to Molnár, obligatory hosts are only *Gobio gobio* and *Phoxinus phoxinus*, in which all females attain maturity.

Life cycle. *Thw. abdominalis* was studied by seasonal dissections of *Ph. phoxinus* and *G. gobio*. The fish become infected when they swallow *Cyclops* containing larvae of the nematode in June and July. Juvenile parasites, with a pointed tail like the larvae, were found at this time in the abdominal cavity of the hosts. During the summer,

developing nematodes were found under the mucosa of the swim bladder, where copulation takes place. Developing females usually remained in the abdominal cavity in August and September. Males and unfertilized females were found during the whole year under the mucosa of the swim bladder; they do not grow.

Females which passed into the abdominal cavity were 22–66 mm long in autumn and 60–72 mm in the following spring. The first larvae appear at the beginning of May, and the uterus of females is filled with fully developed larvae 77–110 mm long in the middle of May. At the end of June the females leave the host actively through the anus. They break up in the water; the larvae are released and survive for 3–5 days, attracting the attention of *Cyclops* by their active movements. *Cyclops* is the intermediate host, in which the larvae develop to the infective stage. *Cyclops* collected where fish were caught for study became infected with larvae of *Thw. abdominalis* under laboratory conditions. Mature females could sometimes not leave the abdominal cavity of the host and died in it.

References: Skrjabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 73; Kreplin, 1925, p. 95; Diesing, 1861, p. 42; Linstow, 1874, pp. 122–134; Molnár, 1967, pp. 293–300; 1969, pp. 137–143; Nybelin 1928, pp. 1–4; 1931, pp. 58–64; Rasheed, 1963, pp. 89–130.

Thwaitia bagri Khalil, 1965 (Figure 202)

Host: *Bagrus bayad*.

Localization: under the skin lateral to the mouth.

Distribution: Sudan (Nile).

Description (after Khalil, 1965).

Male unknown.

Female. Length of mature female 20–31 mm. Body of almost uniform width its entire length, width 0.48–0.68 mm, slightly narrowing at the ends. Cuticle smooth and relatively thick. Cephalic end rounded, with 4 large, thick papillae situated on the submedian line; there is also a pair of small amphids which are difficult to see. Width of cephalic end 0.11–0.17 mm.

Mouth simple, surrounded by 3 elevations which form a triangular cone. Mouth opening directly into a short muscular esophagus which is 1.48–1.65 mm long and 0.05–0.08 mm wide. The esophagus is widened anteriorly and then gradually narrows and becomes threadlike. The large esophageal gland opens into the esophagus before the nerve ring and extends along the whole esophagus laterally, ending blind at the end of the esophagus. Nerve ring situated 0.2–0.26 mm from the cephalic end. Intestine relatively thick-walled, wider than the esophagus; its lumen gradually narrows and disappears at the end. The intestine adheres to the wall of the posterior end of the body. Anus absent. The long, cylindrical, reverted ovaries 351 are situated at the ends of the body and vary markedly in position. The large uterus has thin walls and extends through the entire body. It is filled with larvae. Vagina and vulva absent.

Tail blunt, square, with two large, conical lobes, 0.34–0.39 mm wide.

Larvae 0.24–0.31 mm long, 0.016–0.019 mm wide, with blunt cephalic and pointed posterior end. Cuticle with fine striation. Esophagus 0.099–0.143 mm long; intestine containing large granules. Anus situated 0.06–0.066 mm from the posterior end.

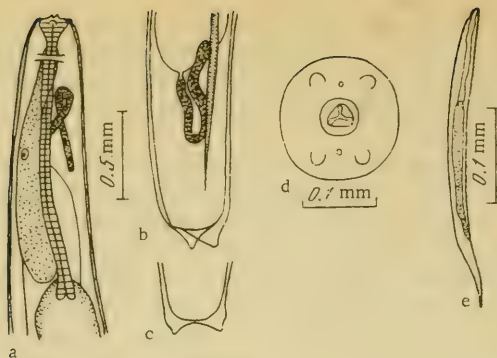


FIGURE 202. *Thwaitia bagri* Khalil, 1965:

a — anterior end of female, lateral; b — posterior end of female, lateral;
c — tail of female, ventral; d — cephalic end, apical; e — larva from
uterus (after Khalil, 1965).

Because of their bright red coloration, the worms are visible under the skin of the fish. When placed in physiological saline, they straighten and some of them live for 2 days at room temperature and slightly longer in the refrigerator. When adult worms enter the water, they straighten and burst in the region of the esophagus, releasing the larvae into the water. After 2–3 hours, all the larvae are discharged and swim free in the water. They survive for about 3 days in tapwater at room temperature. The female then soon dies. Most of the females found under the skin of the fish lateral to the mouth were mature, and only a few did not contain larvae.

Reference: Khalil, 1965, pp. 309–312.

Thwaitia kottani Molnar, 1969 (Figure 203)

Host: *Aspius aspius*.

Localization: body cavity.

Distribution: Hungary.

352 Description (after Molnár, 1969).

Male. Length 2.1–2.6 mm, width 0.041–0.062 mm. Cuticle transparent; body tapering slightly at both ends. Cephalic end rounded, without papillae. Caudal end blunt, with two teatlike processes which are connected by a membrane. Two narrow, short spicules of almost the same length, 0.090–0.10 and 0.082–0.098 mm. Gubernaculum forming a curved chitinized plate with ring-shaped end; it is curved dorsally in about the middle and then dorso-anteriorly; it is 0.053–0.066 mm long.

Female. Length 61 mm, width 1 mm. Red nematodes. Body cylindrical, tapering slightly at both ends. Cephalic end rounded, with 4 indistinct papillae and 3 lips. End of tail rounded; two small teatlike processes on both sides in dorsoventral view. Body cavity entirely occupied by the uterus, which is filled with larvae. Length of larvae 0.44–0.46 mm; cephalic end rounded, posterior end tapering.

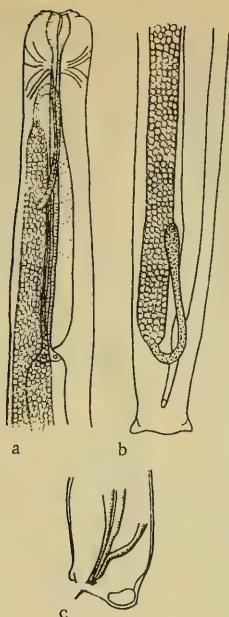


FIGURE 203. *Thwaitia kotlani* Molnar, 1969:

a — anterior end of female, lateral; b — posterior end of female, lateral;
c — posterior end of male (after Molnár, 1969).

Immature females 20–30 mm long have teatlike processes at the posterior end.

Molnár studied the life cycle and gives the following details. *Thw. kotlani* has a one-year cycle. Mature females filled with larvae were found only in May. The discharged larvae enter the water and continue to develop in *Cyclops*. *Aspius aspius* became infected in summer, probably when they swallowed infected *Cyclops* or smaller plankton-feeding fish. After copulation, the males of *Thw. kotlani* remain in the swim bladder throughout the year, and fertilized females settle in the abdominal cavity. It is not known when the females move from the swim bladder into the abdominal cavity, but probably in early autumn, since females 15–20 mm long were found in the body cavity in early spring. The uterus of such females was filled with eggs in the early stages of development. At the beginning of April the females were 25–30 mm long and the eggs were already ripe. Older larvae hatch in May.

Reference: Molnár, 1969, pp. 137–143.

353 *Thwaitia rischta* (Skrjabin, 1917) (Figure 204)

Synonym: *Philometra rischta* Skrjabin, 1917

Hosts: *Pseudaspius leptocephalus*, *Aspius aspius*.

Localization: under the skin of the head.

Distribution: Europe, Asia.

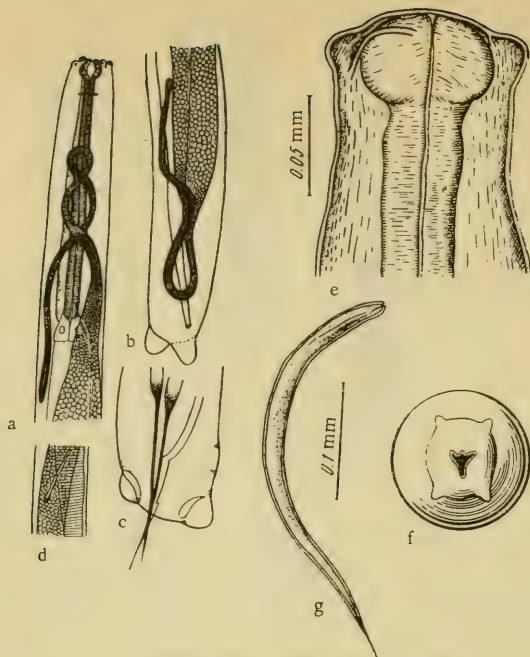


FIGURE 204. *Thwaitia rischta* (Skrjabin, 1917):

a — anterior end of female; b — posterior end of female; c — posterior end of male;
d — fragment of female; e — anterior end, lateral; f — cephalic end, apical;
g — larva (a-d — after Molnár, 1966b; e-g — after Lewaschoff, 1929).

Description (after Skrjabin, 1923b, as *Philometra rischta*).

Male not described.

Female. Length 17 to 20 mm. Measurements of a female 19 mm long and 0.6 mm wide in the middle of the body. Cephalic end 0.1 mm wide, posterior end 0.25 mm wide. Width at level of posterior part of esophagus 0.39 mm. Cephalic end slightly blunt, with 4 distinct, hemispherical, convex tubercles arranged symmetrically on the lateral lines and on the dorsal and ventral line. In the middle of the rectangular field formed by these tubercles is the trihedral mouth, which leads into the strongly muscular esophagus. The first part of the esophagus is slightly swollen and separated from the other part by a constriction; however, the esophagus does not form a funnel-shaped invagination anteriorly. Length of esophagus 1.345 mm, width 0.12 mm in the posterior part. On the dorsal side, in the wall of the esophagus, there is a large gland with a large nucleus. Intestine extending almost to the end of the body, ending blind. The posterior end has a distinctive structure; it consists of two lateral teatlike processes directed obliquely laterally, situated 0.25 mm from each other. Between the lateral processes the posterior margin forms a more or less deep crescent-shaped invagination.

The anterior end of the large uterus is situated 0.255 mm from the cephalic end, the posterior end 0.73 mm from the posterior end. At the posterior end of the uterus begins the small, slightly twisted ovary, which extends posteriorly in the form of a thin, cylindrical appendage. The uterus is filled with developed larvae which are 0.357 mm long, 0.017 mm wide at their thickened cephalic end.

Description (after Lewaschoff, 1929, as *Philometra rischta*). Cuticle thin, smooth. Cephalic end with 4 large conical processes situated submedially. The anterior end is slightly laterally flattened so that these processes are arranged in pairs slightly more close together on the dorsal and ventral side. Mouth forming a triangular slit. Beginning of esophagus swollen like a club, strongly muscular. This swelling passes abruptly into the other part of the esophagus, which is narrower and long 0.05 mm from the anterior end.

Male not described.

Female. Length 20.66–31.11 mm. Width 0.49–0.70 mm, but varying in different parts of the body: 0.12–0.13 mm at the end of the "head," 0.45–0.61 mm at the posterior end of the esophagus, and 0.18–0.29 mm at the posterior end. Length of esophagus 2.16–2.45 mm, width in the posterior part 0.01–0.07 mm. Vulva and anus not found. Uterus with thin walls and so distended with larvae that the intestine is pressed against the body wall.

The larvae are situated 0.74 mm from the cephalic end and 0.13 mm from the caudal end. Length of larvae 0.369 mm, width at the cephalic end 0.013 mm.

Description (after Molnár, 1966a).

Male. Length 1.68–2.00 mm, width 0.022–0.039 mm. Cuticle transparent, smooth. Cephalic end rounded, with 4 circumoral papillae. It narrows toward a slightly constricted "neck." Behind the neck the body is almost of the same width as the cephalic end. Posterior end with lateral teatlike processes which are connected dorsally by a narrow lobe.

355 Spicules of almost the same length, 0.045–0.057 and 0.045–0.053 mm.

Width of spicules at the end 0.003 mm. Gubernaculum 0.031–0.041 mm long, forming a curved chitinized plate.

Female. Mature females yellowish red, length 30–32 mm, width 0.8–1.0 mm. Body tapering slightly at both ends. Cuticle smooth. Cephalic end with 4 distinct papillae and 3 lips. Posterior end with two distinct, lateral, teatlike processes. Uterus filled with larvae, occupying almost the entire body cavity, pressing the esophagus and intestine to the body wall. Anus subterminal.

Length of young females 5–7 mm. Coloration yellowish red or red. Cuticle smooth. Body of almost uniform width its entire length, tapering slightly at the ends. Posterior end with two teatlike processes. Cephalic end with 4 distinct papillae and 3 lips. Esophagus cylindrical, forming a bulb anteriorly. Its posterior end is connected with the wide intestine by valves. The esophagus is serrated from the bulb to the valves; it contains an esophageal gland which becomes gradually thicker, being twice as wide as the esophagus in the middle, and then gradually narrows again, ending in the esophageal valves. Intestine of uniform width its entire length, narrowing posteriorly and ending in the subterminal anus. Nerve ring situated behind the esophageal bulb. Vulva rounded, situated in the posterior third of the body; vagina chitinized, 0.004 mm wide, extending anteriorly for 0.019–0.021 mm. Uterus forming a sac, filled with eggs,

narrowing at both ends in young specimens; in older specimens it passes into the tubular ovaries. The anterior ovary begins from the uterus near the esophageal valves and makes several loops at the level of the esophagus, turns and ends at the anterior end of the uterus. The posterior ovary forms loops near the rectum and turns, ending around the uterus.

The life cycle was studied by Molnár (1966a), who found that *Thw. rischta* has an annual life cycle.

Adult females of *Thw. rischta* 35–42 mm long were found at the end of May and in early June on the inner surface of the operculum, sometimes under the skin of the head, in the orbit, rarely at the base of the anterior fin. One to 35 specimens were usually found in a host.

Males were found only in summer. There were usually 2 specimens under the serosa of the posterior part of the swim bladder; one male was found on the caudal fin. A single male was found in the swim bladder of *Aspius aspius* in May; females were not found in this specimen.

Fish 2 years old and more become infected with larvae of *Thw. rischta* at the end of June.

Males 1.53–1.92 mm long and 0.024–0.031 mm wide and females 1.04–1.057 mm long and 0.031–0.037 mm wide were first found in the swim bladder in early July. In the middle of July only males 1.78–2.73 mm long and 0.029–0.037 mm wide were found in the swim bladder of several specimens of *Alburnus*.

356 In the middle of August females and males disappeared from the swim bladder, and several juvenile females 1.30–2.73 mm long and 0.033–0.105 mm wide were found on the inside of the operculum and in other parts of the head. In heavily infected fish (over 25 specimens) immature females 3.56–6.57 mm long and 0.114–0.217 mm wide were found in September in the muscles near the pectoral fin. In autumn the females continue to develop and become 5.6–6.8 mm long and 0.20–0.26 mm wide at the end of October. In early April, the females are 8.21–22.50 mm long and 0.26–0.47 mm wide and contain nonsegmented eggs 0.014–0.019 mm wide. Segmentation of the eggs continues in early May and reaches the morula stage; the slightly oval eggs are 0.038–0.042 mm wide. From 10 to 20 May an elongate developing embryo is visible, and at the end of May the uterus is filled with mobile first-stage larvae.

Mature females 35–42 mm long leave the host at the end of May or in early June.

Fish examined after 10 June showed only tissue lesions caused by *Thw. rischta*. When they enter the water, females of *Thw. rischta* burst, and the first-stage larvae are released. They are 0.280–0.430 mm long at this time. Molnár stated that *Cyclops strenuus*, *Macrocylops albidus*, and *Acanthocyclops viridis* are very susceptible to infection with this parasite; however, 100% infection may take place only in young population of crustaceans. Only a third of adults become infected.

References: Skrjabin, 1923b, pp.1–9; Skrjabin, Shikhobalov, Sobolev, Paramonov, and Sudarikov, 1954, p.78; Lewaschoff, 1929, pp.121–128; Molnár 1966a, pp.227–241; 1966b, pp.147–149.

Thwaitia sp. (Linton, 1910) Rasheed, 1963

Synonym: *Ichthyonema sanguinea* Linton, 1901

Host: fish.

Localization: body cavity.

Distribution: Europe.

Description (after Linton, 1910).

Male unknown.

Female. Length 30 mm, width 0.81–1.0 mm; width of cephalic end 0.23 mm. Adults long and narrow, slightly truncate at the cephalic end. Four lips, each with two papillae. Esophagus at first slender, gradually widening; length 1.14 mm, width 0.1 mm at the beginning and 0.17 mm at the end. Intestine at first slightly wider than esophagus. Uterus large, occupying the greater part of the body cavity and filled with embryos.

References: Linton, 1901, pp. 441–481; Rasheed, 1963, pp. 89–130.

Thwaitia translucida (Walton, 1927) Rasheed, 1963

(Figure 205)

Synonym: *Philometra translucida* Walton, 1927

Host: *Esox lucius*.

Localization: abdominal cavity.

Distribution: North America.

Description (after Walton, 1927, as *Philometra translucida*).

Male unknown.

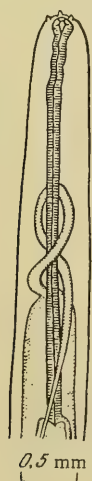


FIGURE 205. *Thwaitia translucida*
(Walton, 1927).

Anterior end (after Walton, 1927).

Female. Length 75 mm, width 0.75 mm. Cephalic and caudal end truncate. Body whitish, transparent, delicate but resilient. Lateral lines wide and transparent. Mouth surrounded by 4 small but distinct papillae,

esophagus with a distinct bulb anteriorly. Length of esophagus 4 mm, width 0.18 mm. Intestine oval, 0.3 mm wide. Esophageal gland small and opaque. The opposite uteri extend from the connection between the esophagus and the intestine for 6/7 of the length of the body. The two ovaries consist of short, winding tubes which extend from each end of the uterus. Vulva and vagina not recognizable. Eggs spherical, 0.040–0.050 mm wide.

Reference: Walton, 1927, p. 89.

SUBFAMILY *PHILONEMINAE* N. SUBFAM.

Historical review

Chitwood (1937) placed the genus *Philonema* in the subfamily Philometrinae, but stated that the position of the genus in this subfamily is doubtful, since the esophageal glands are polynuclear but the larvae are of the dracunculoid type. Chitwood and Chitwood (1950) also stated that *Philonema* shows an extreme development of the esophageal gland in the Dracunculoidea; the species of this genus have a typical spiruroid-filarioid esophagus.

Skrjabin et al. (1954) provisionally kept the genus *Philonema* in the subfamily Philometrinae.

A study of the life cycle of *Philonema oncorhynchi* (Platzer, 1964; Platzer and James, 1967; Adams, 1969) showed that development in the definitive host may last as long as 3 years.

Because of the above morphological and biological characteristics of the species of *Philonema*, we consider it justified to establish the subfamily Philoneminae n. subfam. for this genus.

Diagnosis. Philometridae. Esophagus divided into a narrow muscular anterior part and a widened glandular posterior part. Esophageal gland polynuclear. Posterior end of males long and thin, tapering.

Type genus: *Philonema* Kuitunen-Ekbaum, 1933.

358 Genus *Philonema* Kuitunen-Ekbaum, 1933

Synonym: *Coregonema* Bauer, 1946

Historical review

The genus was established when Kuitunen-Ekbaum described a new nematode from Salmonidae, *Philonema oncorhynchi*. Simon and Simon (1936) and Fujita (1939, 1940) described six further species of the genus.

After a study of specimens of *Philonema* from fish near Kamchatka and comparison with the descriptions of species of the genus *Philonema* and *Coregonema* Bauer, 1946, Akhmerov (1955) identified his specimens with *Philonema oncorhynchi* Kuitunen-Ekbaum, 1933 and questioned the validity of the species of the genus *Philonema*. He

considered *Philonema agubernaculum* Simon and Simon, 1936 and *Ph. elongata* Fujita, 1940 as synonyms of *Ph. oncorhynchi* and assumed (he did not know Fujita's work of 1939) that the specific characters of *Philonema kondai*, *Ph. salvelini*, *Ph. tenuicauda*, and *Ph. ochotense* (Fujita, 1939) are not convincing and that they are probably also synonyms of *Ph. oncorhynchi*. He also stated that *Ph. oncorhynchi* and *Coregonema sibirica* Bauer, 1946 are indistinguishable, but their hosts and ecology are completely different: the hosts of *Ph. oncorhynchi* are Salmonidae, the hosts of *C. sibirica* Coregonidae; the Salmonidae are anadromous fishes and their adults live in the sea, while the Coregonidae live in fresh water. These ecological characters also refer to the nematodes parasitizing them: *Ph. oncorhynchi* is a marine species, *C. sibirica* a freshwater species. The differences in size of these species do not exceed the boundaries of genus and species, and therefore Akhmerov made *C. sibirica* Bauer, 1946 a synonym or a subspecies of *Ph. oncorhynchi* and the genus *Coregonema* a synonym of the genus *Philonema*.

In a study of the migrations of Salmonidae in the Far East, Mamaev et al. (1959) established that *Ph. oncorhynchi* is a freshwater form, and they therefore proposed that the species and the subspecies *Ph. oncorhynchi sibirica* should be considered as a freshwater species.

Rumyantsev (1965), who first recorded *Ph. sibirica* from the European USSR (Karelia), also considered *Coregonema* as a synonym of *Philonema*, but he thinks that *sibirica* is a valid species, quite distinct from *Ph. oncorhynchi*. As to *Ph. elongata* Fujita, 1940, Rumyantsev agreed with Akhmerov (1955) that it is a synonym of *Ph. oncorhynchi* and suggested, quoting Tamao (1960) and Meyer (1960), that *Ph. kondai*, *Ph. salvelini*, and *Ph. tenuicauda*, described by Fujita (1939), are also synonyms of *Ph. oncorhynchi*.

Rasheed (1963) placed 6 species in the genus *Philonema*: *Ph. oncorhynchi*, *Ph. agubernaculum*, *Ph. elongata*, *Ph. kondai*, *Ph. salvelini*, and *Ph. tenuicauda*.

After reading the descriptions of Fujita (1939, 1940), we agree with Akhmerov and Rumyantsev and consider the species described by him as synonyms of *Ph. oncorhynchi*. Bashirullah (1967) published a short communication on the development of the species of the genus *Philonema* in Salmonidae with different life cycles. The study was made to establish the identity of *Philonema oncorhynchi* from the anadromous *Oncorhynchus nerka* and *Ph. agubernaculum* from freshwater 359 trout, and because of the differences in the life cycles, cross infections, and the protein composition of the parasites, he considered *Ph. oncorhynchi* and *Ph. agubernaculum* as different species. He also transplanted adult *Ph. oncorhynchi* (but without larvae) from almost mature sockeye salmon into immature trout. The larvae did not develop in trout.

We therefore recognize 3 species in the genus *Philonema*: *Ph. oncorhynchi*, *Ph. agubernaculum*, and *Ph. sibirica*.

Diagnosis. *Philoneminae*. Females markedly larger than males; body threadlike; anterior end rounded, posterior end elongate; mouth with lips or papillae or without them; esophagus cylindrical, esophageal gland polynuclear.

Male. Posterior end elongate and spirally twisted; anus subterminal; spicules of the same length; gubernaculum absent.

Female. Anus and vulva atrophied in adults; body cavity occupied by the uterus, which contains developed larvae. Two short ovaries situated at the ends of the body.

Parasites of the body cavity and, possibly, of the connective tissue of fish.

Type species: *Philonema oncorhynchi* Kuitunen-Ekbaum, 1933.

Philonema oncorhynchi Kuitunen-Ekbaum, 1933

(Figure 206)

Synonyms: *Philonema kondai* Fujita, 1939; *Ph. ochotense* Fujita, 1939; *Ph. salvelini* Fujita, 1939; *Ph. tenuicauda* Fujita, 1939; *Ph. elongata* Fujita, 1939

Hosts: *Oncorhynchus nerka*, *O. keta*, *Salvelinus leucomaenis*.

Localization: body cavity, connective tissue.

Distribution: British Columbia.

Description (after Kuitunen-Ekbaum, 1933a).

Male. Length 35 mm, width 0.35 mm. Mouth simple. Esophagus consisting of an anterior part and a longer posterior part. Length of esophagus 2.4 mm. Posterior end tapering and spirally coiled. Anus subterminal, situated 0.35 mm from end of tail. Several pairs of postanal papillae present. Spicules of the same length, 0.4 mm long, 0.007 mm wide, curved. Gubernaculum absent.

Female. Length 360 mm, width 1.3 mm. Body brilliant white, live specimens semitransparent. Cephalic end rounded, mouth simple, without lips or papillae. Esophagus cylindrical, 2.4 mm long. Intestine extending as a flat, dark ribbon throughout the entire body and ending blind, adhering to the body wall with a muscle cord. Anus and vulva atrophied in mature females; the body cavity is almost completely occupied by the uterus, which is filled with larvae; there are two short ovaries, one at each end of the body. Posterior end tapering, slightly twisted. Length of larvae in the uterus 0.54 mm, width 0.03 mm. The body of the larvae tapers posteriorly and ends in a long, thin tail which is as long as the body. Mouth with two small papillae. A thin esophagus and the intestine are visible.

Kuitunen-Ekbaum stated that females of *Ph. oncorhynchi* placed in seawater discharge numerous larvae which die in 2 days.

360 Description (after Fujita, 1940). Body thin, cephalic end widened, posterior end elongate. Cuticle thick, striated with intervals of 0.008 mm on the cephalic and posterior parts. Papillae indistinct. Mouth narrow, slitlike. Length of short, narrow muscular part of esophagus 0.9 mm, width 0.09 mm. Anterior part of esophagus widened to 0.15 mm, with a
361 thick wall. Posterior part of esophagus 1.6 mm long and 0.16 mm wide. Intestine narrow, to 22 mm long and 0.09 mm wide. Rectum and anus usually atrophied; rectum 0.25 mm long in young forms, anus situated 0.063 mm from the posterior end. Nerve ring situated 0.5 mm from the cephalic end; excretory pore not recognizable.

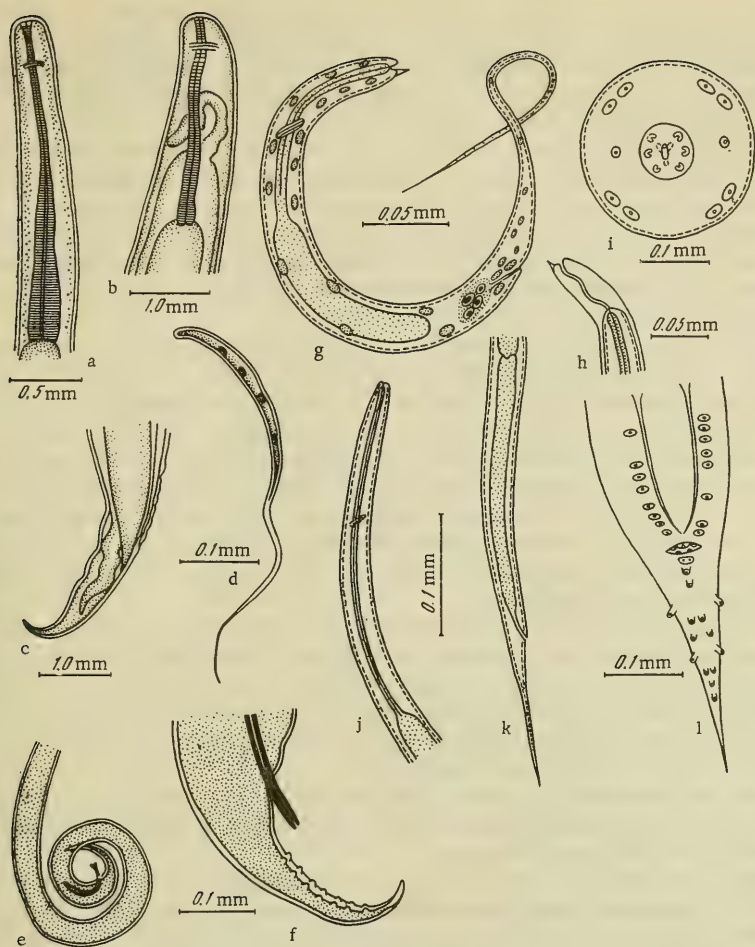


FIGURE 206. *Philonema oncorhynchi* Kuitunen-Ekbaum, 1933:

a, b — anterior end; c — posterior end of female; d — larva; e, f — posterior end of male, different aspects; g — first-stage larva, lateral; h — second-stage larva, cephalic end; i — cephalic end of young female, apical; j — anterior end of third-stage larva; k — posterior end of third-stage larva; l — posterior end of young male, ventral (a-f — after Kuitunen-Ekbaum, 1933; g-l — after Platzer and Adams, 1967).

Male. Length 35 mm, width 0.3 mm. Two spicules, 0.39 mm long, with pointed end. Caudal papillae rounded and sessile; 4 pairs of preanal papillae arranged in two groups; six pairs of postanal papillae in one group. Caudal wings dark.

Female. Length 100 mm, width 0.9 mm. Genitalia paired. Vulva and vagina atrophied in adults. Vulva of immature females situated slightly before middle of body. Vagina 1 mm long, directed posteriorly; uterus thin, markedly widening.

The life cycle of *Ph. oncorhynchi* was studied by Platzer (1964) and Platzer and James (1967) in Lake Cultus (Canada), where the intermediate host is *Cyclops bicuspidatus*. Development in the definitive host was observed in naturally infected young sockeye salmon which had been kept in fresh water for 2 years.

Mature females of *Ph. oncorhynchi* burst in fresh water after a minute. The larvae discharged remain suspended in the water for several days; some first-stage larvae may live for 17 days in lake water at 8°C. *Cyclops* swallow suspended larvae and larvae lying on the bottom. There were usually one or two larvae in the body cavity of a *Cyclops*, but sometimes as many as seven. Differences in the behavior of infected and uninfected *Cyclops* were not observed.

The first-stage larvae have a long, threadlike tail which tapers sharply. Mouth surrounded by papillae, with a triangular denticle dorsally. Esophagus apparently not divided, with numerous refracting particles. Nerve ring situated almost in middle of esophagus. Intestine consisting of 18–30 cells with a distinct nucleus, not united with the proctodeum. The genital primordium consists of 4 cells, the nucleus of which contains a large quantity of confluent chromatin. Rectum with thin wall, anus distinct.

Second-stage larva. After 25 days at 8°C and 17 days at 12°C infected *Cyclops* contained molted larvae, but the cuticle of the first-stage larva had not been shed.

The second-stage larva is shorter than the first-stage larva and shows the following differences: dorsal tooth absent, intestine narrow, nuclei protruding above the surface of the intestine, rectum thicker, tail shorter and sharply tapering; genital primordium not visible; the larvae did not move actively in the hemocoel but made slow bending movements in response to the movements of the host.

At the end of the second stage the larvae were as long as the first-stage larvae, and the esophagus was already divided into a narrower muscular part and a thicker glandular part.

Third-stage larvae were found in some *Cyclops* after 17 days at 12°C. They differ from the late second-stage larvae as follows: glandular part of the esophagus distinct, occupying half the length of the larva and filling the pseudocoel; larvae very mobile, both in the body cavity and 362 outside it; rectum narrow, with thin wall; distinct esophageal-intestinal valves projecting into the intestine.

The body cavity of *Cyclops* is almost entirely filled with second-stage larvae.

Third-stage larvae from an experimentally infected fish were identical with larvae from *Cyclops*. However, larvae removed from fish 4 and 5 days after infection were smaller than third-stage larvae from *Cyclops*. Larvae taken from fish 9–10 days after infection were of the same size as the larvae from *Cyclops*. Younger larvae are distributed mainly in the peritoneum near the body wall and in the serosa of the swim bladder; older larvae are localized mainly in the wall of the swim bladder.

Fourth-stage larvae appear after 15 months. Average length of female larva 4.80 mm, of male larva 3.90 mm. Uterus of female didelphic, vulva not fully developed. The genital duct of the male is connected with the ventral wall of the cloaca, but the spicules are not yet fully developed.

This stage was later found in the body cavity together with the subimagines, which appear after 20 months. Several subimagines were found in the fish earlier than fourth-stage larvae.

Subimaginal females 42 mm long had a large uterus, ovaries, and a vulva. A subimaginal male 18 mm long had spicules, anal papillae, a tridentate gubernaculum, and genital ducts with regional differentiation and mobile sperm.

The cephalic and caudal papillae are indistinct in adults, and have therefore not been described. They are distinct in immature live specimens or in specimens which have just died but have not yet been fixed. The preanal papillae are sessile; the postanal papillae project above the cuticle. The papillae of both types contain nerve endings. The papillae are arranged in pairs and singly, and their number is not constant. There are 10 pairs of preanal papillae, 2 pairs in the depression of the cloaca, and 10 pairs of postanal papillae. The mouth is slitlike and surrounded by an inner ring of 6 sickle-shaped papillae, an outer ring of 4 pairs of papillae, and a pair of amphids behind the interolateral papillae.

The authors noted the long period of development in the definitive host, probably caused either by the low water temperature required by the host (*Salmonidae*) or by adaptation of the parasite: the protracted development of the nematodes coincides with the development of the host. Females of *Ph. oncorhynchi* are usually filled with developed first-stage larvae when the salmon spawns.

The fish probably become infected in January–February, since young salmon do not leave the lake for the sea before April and can therefore contain a large number of infective larvae in the wall of the swim bladder.

The authors observed that the larvae begin to develop in the swim bladder only at the age of 18 months, that is, about 6 months after the migration of the salmon to the sea. At the age of 32 months, when the fish usually begin to migrate to fresh water for spawning, almost adult nematodes are present in the body cavity. During the migration, the gonads of the fish increase in size, and the parasites grow and mature accordingly. Fish ready to spawn contain nematodes, the uterus of which is filled with 363 developed larvae. When the fish arrive at the spawning grounds, the larvae are ready to leave the uterus.

The authors assumed that such an exact correlation between the development of larvae of *Ph. oncorhynchi* and the maturation and spawning of their host is determined by hormones of the salmon.

Bashirullah (1967) experimentally established that the rapid development of *Ph. oncorhynchi* is parallel to the rapid development of the gonads of the fish during the last 6 months of its life: immature salmon contained only immature nematodes, but females of *Ph. oncorhynchi* containing larvae were found only in mature fish aged 2, 3, and 4 years.

References: Akhmerov, 1955, pp. 99–137; Rummyantsev, 1965, pp. 1082–1083; Skryabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 80; Bashirullah, 1967, p. 3332; Fujita, 1939, pp. 260–262; 1940, pp. 389–390; Kuitunen-Ekbaum, 1933a, pp. 71–75; Platzer, 1964, p. 561; Platzer and Adams, 1967, pp. 41–43; Rasheed, 1963, pp. 89–130; Smedley, 1933, pp. 169–179.

Philonema agubernaculum Simon and Simon, 1936
(Figure 207)

Hosts: Salmonidae — *Prosopium williamsoni*, *Salvelinus fontinalis*, *Salmo shasta*.

Localization: body cavity.

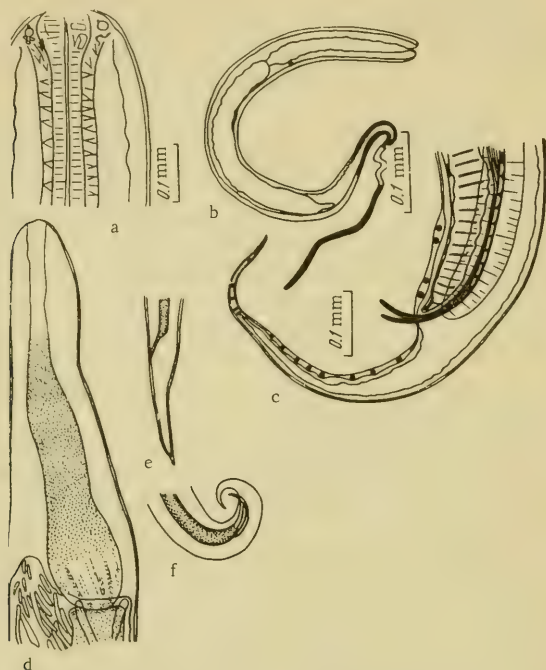


FIGURE 207. *Philonema agubernaculum* Simon and Simon, 1936:

a — cephalic end; b — larva; c, d — posterior end of male, lateral; d — anterior end; e — posterior end of female (a—c — after Fujita, 1940; d—f — after Simon and Simon, 1936).

364 Distribution: North America.

Description (after Simon and Simon, 1936).

Male. Length 12–23 mm, width 0.296 mm. Esophagus muscular-glandular, cylindrical, 1.526 mm long, 0.189 mm wide. Length of muscular anterior part 0.404 mm. Anus situated 0.276 mm from end of tail. Spicules of the same length, markedly curved, weakly chitinized, 0.284 mm long on the outside of the curve. Gubernaculum absent.

Female. Length 49–140 mm, width 0.771 mm. Length of esophagus 1.725 mm, width 0.220 mm; length of anterior part 0.553 mm. Anus situated 0.446 mm from end of tail. In females with eggs the anus is sometimes atrophied, and vulva and vagina are completely atrophied. The uterus of mature females is filled with embryos and occupies almost the entire body cavity. The uterus of young females contains eggs at different stages of development, 0.032×0.046 mm large. Length of embryo 0.343 mm.

Meyer (1958, 1960) and Vik (quoted in Platzner and Adams, 1967) studied the development of *Ph. agubernaculum* in *Salvelinus fontinalis* and *Salmo salar*. They assumed that adult females leave the fish when they spawn, and the larvae are released when the females burst in the water. Meyer and Vik infected *Cyclops* sp. with larvae of *Ph. agubernaculum*. However, when they fed the infected *Cyclops* to the trout, it did not become infected. Vik obtained larvae of *Ph. agubernaculum* from the tissues of *Osmerus mordax* by pepsin digestion and infected trout with them. However, he thought that further experiments are necessary to determine the part played by *Osmerus* in the life cycle of *Ph. agubernaculum*.

References: Skrzabin, Shikhobalova, Sobolev, Paramonov, and Sudarikov, 1954, p. 80; Meyer, 1958, p. 42; 1960; Simon, 1936, pp. 440-442.

Philonema sibirica (Bauer, 1946) Rummyantsev, 1965
(Figure 208)

Synonym: *Coregonema sibirica* Bauer, 1946

Hosts: Coregonidae.

Localization: body cavity.

Distribution: water bodies in the north of the USSR.

Historical review

The original description of the species (1946) was very brief and a drawing was not given. Bauer established the new genus *Coregonema*, but the diagnosis was not sufficiently detailed and the key given by the author gave only differences of two genera: *Philometra* and *Dracunculus*. Several studies had appeared by 1948 in which records of the species were given and the list of its hosts was enlarged, proving that the species is widely distributed in Siberia.

Akhmerov (1955) made *Coregonema* a synonym of the genus *Philonema* and *C. sibirica* a subspecies of *Ph. oncorhynchi*. Rummyantsev stated in 1965 that *Coregonema* is a synonym of the genus *Philonema* after a study of the parasites of *Coregonus albula*.

365 Description (after Bauer, 1946, as *Coregonema sibirica*). Lips absent. Mouth without appendages. Lumen of esophagus widening like a funnel at the beginning. Anterior end rounded, posterior end pointed. Males 10-15 times shorter than females.

Male. Length to 16 mm. Length of esophagus 2 mm. Glandular part of esophagus 1.35 mm long, muscular part 0.65 mm. Spicules of the same length, 0.350-0.360 mm. Length of gubernaculum 0.120 mm.

Female. Length to 150 mm. Length of glandular part of esophagus 0.9 mm, of muscular part 0.5 mm. Anus and vulva atrophied in mature females. Viviparous.

Description (after Rummyantsev, 1965).

Male. Length 11.2 mm, width 0.16 mm. Length of esophagus 1.04 mm, width 0.11 mm. Muscular part of esophagus shorter than glandular part, 0.43 mm long. Ratio of length of muscular to glandular part = 1:1.5.

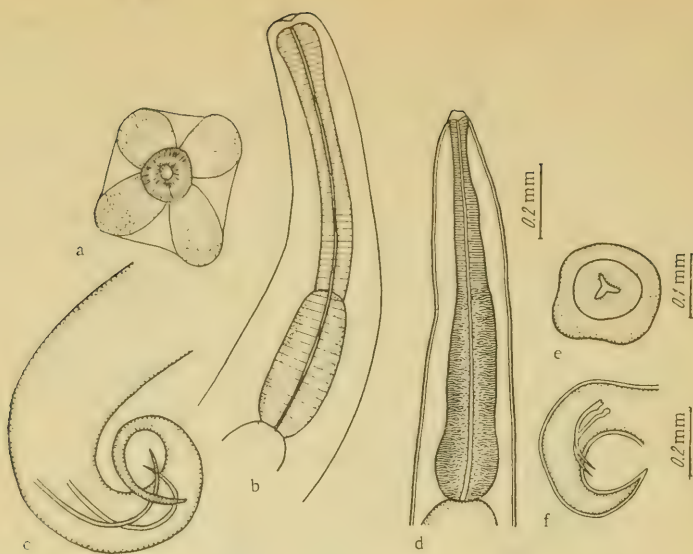


FIGURE 208. *Philonema sibirica* (Bauer, 1946):

a — cephalic end, apical; b — anterior end; c — posterior end of male; d — anterior end;
e — cephalic end, apical; f — posterior end of male (a—c — after Bauer, 1946; d—f —
after Rummyantsev, 1965).

Tail pointed and spirally twisted. Spicules of the same length, distinctly curved, 0.25 mm long and 0.006 mm wide. Gubernaculum absent.

Female. Length 30 mm, width 0.36 mm. Cephalic end rounded, with a simple mouth. Length of esophagus 1.17 mm, width 0.19 mm. Length of muscular part of esophagus 0.49 mm. Lumen of esophagus slightly widened at the beginning. Posterior end narrowing to a straight or slightly curved, pointed process.

366 References: Akhmerov, 1955, pp. 97—137; Bauer, 1946, p. 16; 1968a, pp. 97—156; 1968b, pp. 157—174; Bauer and Greze, 1948, pp. 186—194; Bauer and Nikol'skaya, 1948, pp. 175—176; Petrushevskii and Bauer, 1948, pp. 217—231; Rummyantsev, 1965, pp. 1082—1083.

Philonema sp. Naidenova and Nikolaeva, 1968
(Figure 209)

Host: *Trigla pini*.

Localization: body cavity.

Distribution: Aegean Sea.

Description (after Naidenova and Nikolaeva, 1968). Cephalic end rounded, posterior end pointed. Mouth simple, without lips but with papillae. Male unknown.

Female. Length 2.0—2.5 mm, width 0.264—0.279 mm. Esophagus slightly widened anteriorly and posteriorly, cylindrical, 0.238—0.248 mm long

and 0.009—0.016 mm wide. Anus and vulva atrophied. The two short ovaries are situated at both ends of the body. The loop of the ovary in the anterior part of the body does not extend beyond the connection between esophagus and intestine. Body cavity of females occupied by the uterus with developing embryos 0.120—0.150 mm long and 0.006—0.009 mm wide.

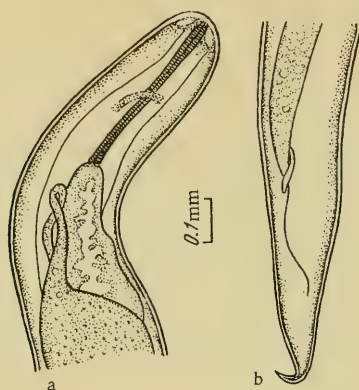


FIGURE 209. *Philonema* sp. Naidenova and Nikolaeva, 1968:

a — anterior end; b — posterior end of female (after Naidenova and Nikolaeva, 1968).

Reference: Naidenova and Nikolaeva, 1968, p. 74.

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